
Wilson's
Natl. Philosophy

26

THE WORLD,

On the Plane of the Horizon of London.

LOWER HEMISPHERE.

The dotted Circles are 1000 miles apart from one another and show the distance of any place in this Hemisphere from the Antipodes of London which occupies its centre.

Reduced by permission from Hughes's Map of The World

London: Darton & Clark 58, Holborn Hill.

THE WORLD,

On the Plane of the Horizon of London.

UPPER HEMISPHERE

The dotted Circles are 1000 miles apart from one another and show the distance of any place in this Hemisphere from London which occupies its centre.

Reduced by permission from Hughes's Map of The World

London: Darton & Clark. 58, Holborn Hill.

LESSONS

IN

NATURAL PHILOSOPHY,

For Children.

LONDON:
DARTON & CO., 42, PATERNOSTER ROW.
1867.

CONTENTS.

FIRST SERIES OF LESSONS

ON

NATURAL PHILOSOPHY.

FIRST LESSON.

In what town do you live?

In*

In what county?

In*

In what country?

In England, which is a country in Europe.

Do you live on a continent or an island?

On an island.

What is the name of the island on which you live?

England.

* The teachers who make use of this little book are requested to insert such names in the first Lesson, as the location of the pupils or schools may require.

What is an island?

An island is land surrounded by water.

What is a continent?

A very large portion of land, much larger than any island.

How many continents are there?

There are two continents.

What are they called?

The eastern and western continents.

Of which of the great divisions of the earth is the eastern continent formed?

Of Europe, Asia, and Africa.

What is the western continent called?

It is called America.

How is America divided?

It is divided into North and South America.

SECOND LESSON.

In which of the two hemispheres is Europe situated?

In the eastern.

What is a hemisphere?

A hemisphere is half a sphere.

What is a sphere?

A sphere is a solid, which is round like a ball.

Then what is a hemisphere?

It is half a sphere, or half a ball.

Is an orange a sphere?

It is, being nearly round like a ball.

If I cut an orange into two equal parts, what should each of these parts be called?

Half an orange, or half a sphere.

Would half an orange be a hemisphere?

It would: and two halves of an orange are two hemispheres.

How many hemispheres are there in a sphere?

There are two.

Are there no more than two?

No: because two hemispheres make a sphere.

Can I not cut the orange into two other parts and make also two halves?

You can, and they also will be hemispheres.

THIRD LESSON.

If I make a mark round the middle of an orange, when uncut, will it not divide the surface into two hemispheres?

It will: one side of the mark will be one hemisphere, and the other side another.

What is the shape of the world on which we live?

It is round or a sphere.

Then how many hemispheres are there?

Two.

What are they called?

Eastern and western hemispheres.

Why are they called eastern and western hemispheres?

Because the sphere or world is divided by a line that is supposed to be drawn round it from the north pole to the south pole, and that part of the world on one side of this line is called the eastern hemisphere, and the part on the other side of the line is called the western hemisphere.

Can I not divide the world into northern and southern hemispheres?

You can.

How can I divide it?

By drawing the line round the other way, and making it go from east to west.

What is that line called which does divide the world into a northern and a southern hemisphere?

It is called the equator.

Then what is the part north of the line called?

The northern hemisphere.

And what is the part south of this line called?

The southern hemisphere.

In which of them do you live?

I live in the northern hemisphere.

Why do you say that you live in the northern hemisphere?

Because I live north of the line that goes from east to west.

But do you not live in the eastern hemisphere?

I do.

Why do you say you live in the eastern hemisphere?

Because I live east of the line that goes from the north to the south pole.

And why do you live in the northern hemisphere?

Because I live north of the line that goes around the world from east to west.

But are there four hemispheres?

There are only two. If you cut the orange in two, up and down, there will be two hemispheres: but I can cut the same orange in two the other way, and make two hemispheres, an upper and lower hemisphere.

FOURTH LESSON.

What is the world commonly called?

The Earth.

What is the Earth?

It is a planet.

What is planet?

It is a body like the earth which moves round the Sun, and receives light and heat from it.

Is the Moon a planet also?

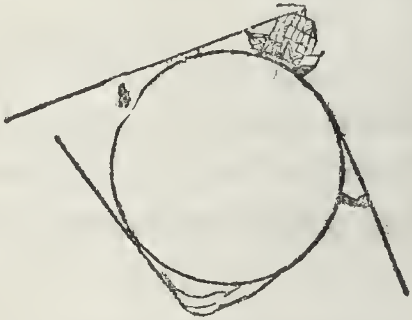
It is a secondary planet or satellite, which moves round the earth.

What is the shape of the world or earth on which we live?

It is round like a ball.

How do you know that it is round?

By observing the approach or disappearance of ships at sea; and by its having been circumnavigated, or sailed round by ships proceeding from a port in one direction until they return to that port again.

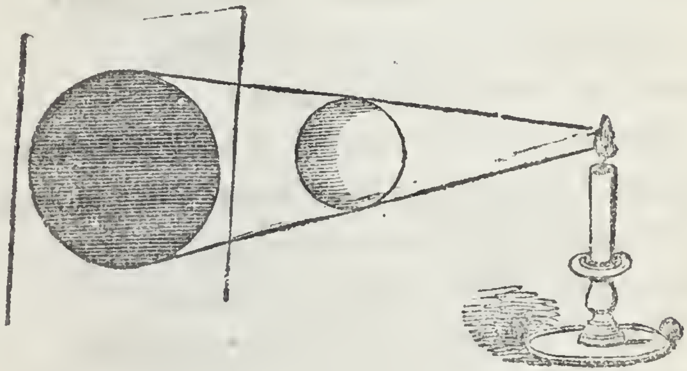


Does the shadow of the earth on the moon in an eclipse of the moon, prove that it is round?

Yes, the shadow being always round, shows that the body producing the shadow must be round.

Then the shadow of a ball is always like a ball or round?

It is.



FIFTH LESSON.

WHAT do you see when you look up into the sky?

In the day when it is not cloudy I see the Sun; and in the night I see the moon and stars, when it is not cloudy.

Is the Earth surrounded by stars?

It is.

Can the people on the other side of the world see them?

They can, when it is night there.

How do you know they can?

Because the stars are all round the world.

Are the stars above us in the day-time?

They are.

How do you know they are?

Some are seen at noon when the Sun is eclipsed.

Can you tell the name of one of them?

Venus is sometimes seen then.

Have you ever seen Venus?

I have sometimes seen it just after sun-set.

When it is seen at that time what is it called?

It is called the *evening star.*

When is it called the *morning star?*

When it is seen before the sun rises.

How can you tell which star is Venus?

It looks larger than the other stars, and is very bright and beautiful.

Is Venus a planet.

It is.

Are all the stars planets?

They are not. Some stars are called planets, and some are called *fixed stars.*

Do the stars shine in the day-time?

They do.

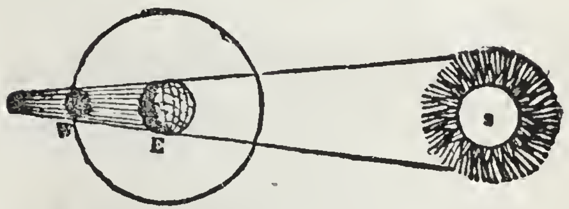
Why can we not see them then as well as in the evening?

Because the light of the sun is so much brighter than their light is.

Do they do us any good in the day-time?

The stars do no more good than a lamp would when the sun shines.

SIXTH LESSON.



WHAT causes the Moon to be eclipsed?

The Earth on which we live passes between the Sun and Moon, and casts her shadow upon it.

Can we not see it when it is eclipsed?

We can see it, but it does not then shine on us.

Is not the Moon a bright object?

It is not; it is dark like the Earth.

Then what makes it shine?

The Sun shining upon it makes it look bright.

Can you explain how the Sun causes the Moon to shine by shining upon it?

If I take the candle out of the room in the evening, and leave the room perfectly dark, the looking-glass is as dark as the other things in the room.

How will it be if you bring back the light into the room?

The looking-glass will appear brighter than the other things. It will shine.

What makes it shine?

It throws the light of the candle back into the room.

When the looking-glass throws back the light that shines upon it, what do we say the looking-glass does?

We say the looking-glass *reflects* the light.

Then when the Sun shines on the Moon, what makes the Moon shine?

The Moon throws back or *reflects* the light of the Sun; and this is what makes the Moon shine.

We do not see the Sun in the night. How can it shine on the Moon when we cannot see it?

If I place the candle in another room, so that it can shine upon the looking-glass, when the door is open, I can see the looking-glass shine from every part of the room, though I do not stand where I can see the candle.

Now, can you tell why we can see the Moon shine, when we cannot see the Sun?

The world turns round every day, and when we are turned away from the Sun, the Sun

can shine on the Moon, and we see the Moon shining when we cannot see the Sun.

Does the Sun shine on half of the Moon at the same time?

It does on that half which is towards the Sun.

When do we see all of that part of the Moon on which the Sun shines?

When the Moon is round, and the whole of it seems to shine.

What is the Moon then called?

It is called the *full Moon.*

Why do we not always see the full Moon?

Because sometimes a part of its bright side is turned away from us.

What is the full Moon?

We call the Moon a full Moon, when the whole of the bright part is towards us.

When is it called *new Moon*?

When in the evening we see but a little of that part on which the Sun shines, we call it the new moon.

Is the Moon made new then every month?

It is not.

When was it made?

When God created the Earth.

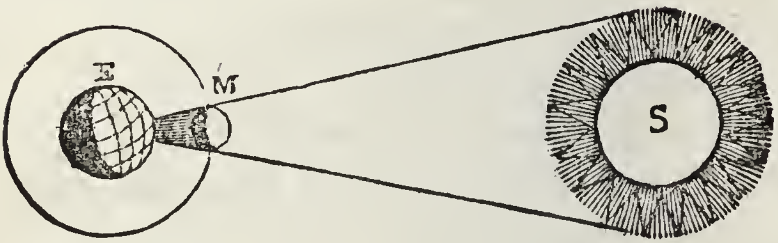
How do you know?

The Bible tells us about it in the first chapter of Genesis.

Who made the Moon?

God made the Moon and the Earth; and he made all things.

SEVENTH LESSON.



What caused the eclipse of the Sun?

The Moon moved between the Earth and the Sun, and hid a part of the Sun from us.

Why did it not hide all the Sun?

Because the Sun is very much larger than the Moon.

How did the Sun look when it was eclipsed?

It looked as if there was a dark round patch upon it.

What makes the *day* and the *night?*

The light of the Sun makes the day, and when the Sun does not shine, it is dark, and we call it night.

But does not the Sun shine all the time?

It does, but we do not see it all the time.

Why do we not see it?

The Earth turns round every day, and one part of the time the Sun shines on one part of the world, and we call it *day;* and when we are turned from the Sun, it does not shine on us, and there is then no more light, and we call it *night.*

When we are turned from the Sun, on which part of the Earth does the Sun shine?

On the opposite half of the earth: it is then day there, and night where we are.

Does the sun *rise* and *set* every day?

It appears to do so, but it does not. We cannot see the Sun move at all.

Then why does it appear to rise every morning, and set every evening?

It is because the Earth turns round every day, and consequently we are carried towards the Sun, and afterwards carried away from it.

Can you explain why the Earth seems to stand still, and the Sun seems to move?

When I am riding very rapidly in a carriage, I am unconscious of my own motion; the houses, fences, trees, &c., seem moving swiftly past me. In the same manner,

whilst the Earth moves rapidly round the Sun, we think that the Sun moves round the Earth, and that we are at rest.

Which way does the Sun appear to move?

From east to west.

What makes it appear to move from east to west?

The Earth turning from west to east.

Which way are we turning in the morning?

Towards the Sun.

And which way are we turning at night?

Away from the Sun.

Did people ever think that the Earth stood still, and that the Sun, Moon, and stars moved around it?

Those who lived a great many years ago thought so.

EIGHTH LESSON.

In what time does the world turn round?

Once in twenty-four hours.

How can you tell?

Because from sun-rise yesterday till sun-rise to-day there are twenty-four hours; and from yesterday noon till noon to-day there are twenty-four hours; and from sun-set

last night till sun-set to-night there are twenty-four hours.

What is a day?

Twenty-four hours.

How many days are there in a week?

Seven.

How many weeks are there in a year?

Fifty-two.

How many months are there in a year?

Twelve.

How many days are there in a year?

Three hundred and sixty-five.

What months are called Spring?

March, April, and May.

What months are called Summer months?

June, July, and August.

Which are the months of Autumn?

September, October, and November.

And which are the Winter months?

December, January, and February.

Which is the first month in the year?

January.

Which day is called New Year's day?

The first day of January.

What makes the year?

The Earth going round the Sun once.

Then in what time does the Earth go round the Sun?

Once in a year.

And in what time does it turn round on its axis?

A day.

What do we call its motion round on its axis?

A rotation.

What do we call its motion round the Sun?

A revolution.

Then how many motions has the Earth?

It has two.

What are they?

One is its rotation on its own axis every day, and the other its revolution round the Sun every year.

NINTH LESSON.

Is the Sun useful to us?

It is very useful.

In what way is it useful?

It gives us light, so that we can see, and it makes us warm.

In what other way is it useful?

It warms the Earth, and makes the plants grow.

What gives the flowers their beautiful colours?

The *light* of the Sun.

What ripens the grain and fruit?

The *heat* of the Sun.

Can you tell one colour from another in the dark?

I cannot.

Is every thing black in the dark?

It is.

How do you know?

If I go into a room that is perfectly dark, I cannot distinguish one object from another.

Suppose I let in a little light?

The colours begin to be seen very faintly.

If I make it quite light, how will they appear?

The colours will be very distinct.

When the room is perfectly dark, how do you know there are no colours in it, though you cannot see them?

If it is light that makes colours, then where there is no light, there can be no colours.

Then the Sun gives you pleasure, does it not?

It does. This world would be a very dismal place without the Sun.

Does the light produce many colours?

It does very many indeed.

Are some colours made by mixing other colours together?

They are: yellow and blue when mixed together make green, blue mixed with red makes purple, and red mixed with yellow makes orange.

Can you tell from whence the light proceeds?

It comes from the Sun.

Has a ray of light ever been divided into distinct parts?

It has been separated into different colours.

Into how many parts may a ray of light be separated?

Into three parts, red, yellow, and blue, which are called primary colours.

How may they be separated?

By a prism.

What is a prism?

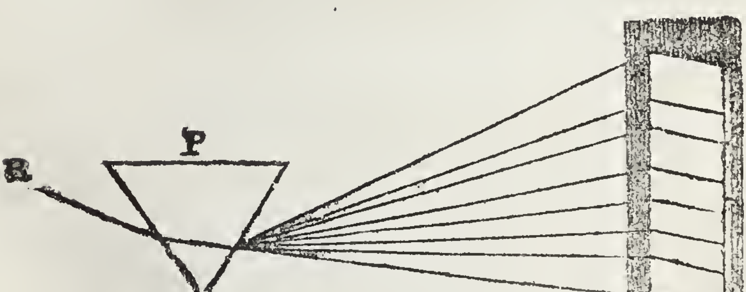
A prism is an oblong piece of glass, having three sides.

But do we not see seven colours with the prism and in the rainbow?

Yes; red, orange, yellow, green, blue, indigo, and violet.

Why is this?

It is because one primary colour overlaps another: thus the red and yellow have an orange between them; so the yellow and blue have a green between them.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A prism is also represented on page 23, having a ray of light passing through it, and separating it into seven colours. Above is the representation of the coloured portions of a rainbow.

What makes the rainbow?

The light of the sun shining through the drops of water while they are falling, makes the rainbow.

How do the drops of water help to make the rainbow?

Each drop of water is like a little prism, and separates the light of the sun, when the sun shines through the drop.

Can a rainbow be seen when there is no water falling?

It cannot.

Do you ever see a rainbow when it rains, unless the sun shines?

I do not.

Then what two things are necessary to make a rainbow?

A bright *sunshine* and a *shower*.

Why is the rainbow so beautiful?

It has beautiful bright colours, and a splendid arch: and when we see it, we remember the promise which God made to Noah, that he would not drown the world again.

Why does the rainbow make you think of that promise?

Because God said that the bow in the cloud should be a sign that he would not drown the world again.

Then when we see the rainbow, is it not as if God were speaking that promise to us?

It is; and it should make us very happy, and grateful to our heavenly Father for such kindness to us, whenever we look at the rainbow in the cloud.

TENTH LESSON.

Can you think of any other way in which the sun is useful to us?

I can: it would not *rain* if the sun did not shine.

Why would it not?

The sun warms the water in the brooks, and rivers, and seas, and makes it rise into the air.

What becomes of the clouds?

When there is much water in them, they become heavy and fall down.

What do we call them when they fall?

We call the water Rain.

What is snow?

Snow is frozen vapour.

What is hail?

Hail is frozen drops of water.

Why is hail heavier than snow?

The arrangement of particles of water in vapour, when frozen, is such as to render it lighter than the frozen drops or hail.

You said the water rose out of rivers, when the sun warmed them; can you tell how rivers are formed?

When it rains, some of the water sinks into the ground.

Where does it go when it has sunk into the earth?

The drops trickle through the earth, and meet other drops that are trickling through the earth, and these run together and form a little stream under ground.

What becomes of the little stream?

It runs along under-ground, till it comes to other little streams, and they run together, and make a larger stream.

And where does it go?

When it comes to a bed of *clay* it stops.

Why does *clay* stop its course?

Because water cannot run through clay.

When the water has filled up the basin made

by the clay, and continues to rise, what becomes of it?

It bursts out at the top of the ground.

What is it called when it bursts out of the ground?

It is called a *spring* of water.

When the water runs along from the spring, what does it make?

A little brook.

Where does the brook run?

It runs along till it meets other little brooks, and thus they make a larger brook: this sometimes grows larger and larger, till it becomes a great river.

And where does the river go?

It runs to the great ocean.

ELEVENTH LESSON.

What do we breathe?

We breathe the air.

Where is the air?

It is above us, and all around us.

By what other name is the air called?

It is called the atmosphere.

Is the air or atmosphere dry?

It is far from being dry.

How do you know it is not dry?

The vapour is rising from the rivers, and seas, and from the moist earth continually: and this vapour mixes with the air we breathe.

Why do we not see these watery particles in fine pleasant weather?

Because they are so very small.

When does the air or atmosphere contain most moisture—in cloudy, or in fair weather?

In fair weather.

How do you know it does?

Because when the sun shines brightest it warms the water in the rivers most, and then a greater number of particles of water rise into the air.

Why does not the air appear as misty in fine weather as it does in cloudy weather?

Because the particles of water in the air are more thoroughly diffused through it.

But what becomes of the vapour in the air when the sun sets, and ceases to warm it?

Part of it remains suspended in the air, forming clouds, and part is changed into water, and may be seen in drops on the leaves and the grass.

What do we call it, when it is on the leaves and grass?

We call it Dew.

On a fine spring morning, we see little particles on the grass like ice: can you tell what they are?

They are the little particles of vapour frozen by the cold.

Now can you tell what hoar-frost is?

Hoar-frost is frozen dew.

When does it freeze?

While it is falling to the earth.

TWELFTH LESSON.

You have told of several ways in which the sun is useful to us: can you recollect any other way in which it is useful?

Oh! yes: the *wind* would never blow if there were no sun.

Why would it not?

The sun heats the air, and when air is hot it rises higher and higher, till it becomes cold again.

What makes warm air rise?

When air is warm, it is lighter than when

cold, and therefore rises in the surrounding cold air.

When it rises, what fills the place the warm air leaves?

The cold air that is around it rushes into the place, as fast as the warm air rises.

How do we speak of the change? or what do we say?

We say the wind blows.

Then what is wind?

Wind is moving air.

When the Sun by shining produces great heat, how does the air rise?

It rises very fast indeed.

Then what does the cold air do?

It rushes in very rapidly all around the place.

And what do we say then?

How very hard the wind blows!

Does the wind always blow hardest in the hottest days in Summer?

It does not. Sometimes in very hot weather we have no wind at all.

Why is there no wind?

The wind blows only when one part of the atmosphere is heated more than the rest; and when parts are equally hot, no cold air can rush in.

But why is there so much more wind in winter than in summer?

The air at the Equator is always hot, and when it rises, the cold air from the north, in winter, rushes toward the Equator more rapidly than in Summer.

What makes the north-west wind so cold?

It is the cold air coming from the cold country far away north-west of us, where it is always colder than it is here.

What makes the chilly north-east wind?

The north-east wind is the air coming from the German Ocean, north-east of us; and it blows the clouds or the vapour from the ocean with it.

What makes the south wind so much warmer than the other winds?

The south wind is the warm air coming from warm countries south of us.

If you were in the central part of South America, what wind would be the coldest?

The south wind.

Why would it be the coldest?

Because it would come from the cold ocean near the cold south pole.

Which wind would be the warmest?

The north wind.

Why would the north winds be warmest?

Because they would come from hot countries, near the Equator.

Where is the hottest region on the earth?

It is the hottest near where the Equator is?

Why is it hottest there?

The Sun always shines straight down, or perpendicularly, on the Equator, or near it, and it does not shine in the same manner on the other parts of the world.

THIRTEENTH LESSON.

When you have been by the sea-side, you have felt the wind blow in the morning and evening regularly; do you know what these winds are called?

People always call them *sea-breezes* and *land-breezes.*

Can you tell what the sea-breezes are?

They consist of cool air coming from the sea in the evening, and flowing over the land which is still heated.

And what are the land-breezes?

They consist of air flowing from the land towards the sea in the morning.

When the wind blows from a hot desert, like

the Desert of Sahara, will the wind be cool or hot?

It will be very hot indeed.

Do you know what these desert winds are called?

Simoom, or Samiel.

What is a hurricane?

A hurricane is a most violent, rotating wind, that often does great injury by blowing down trees, and houses.

Now can you tell what good the wind does?

It makes us cool and very comfortable in the summer.

Does it do any more good that you know of?

It blows off bad air from places where there is or might be dreadful sickness.

What is one of the greatest uses of the wind?

To blow ships across the sea, from one country to another, so that the people can go from one country to another.

Does it ever injure these ships?

It does. Sometimes the wind blows up the waves very high, and they break over the ship, or they toss the ship furiously against the rocks, and dash it into pieces, and the miserable people in it are all drowned.

Who contrived this wonderful plan to purify the air, and to help people to go from one country to another, across the great ocean?

God, our heavenly Father, was the great contriver.

How should we feel, when we see the wonderful things God has contrived?

We should admire, and love, and adore him.

Can you repeat what the Psalmist said about the works of the Lord, in the one hundred and seventh psalm?

Verse 23. They that go down to the sea in ships, that do business in great waters;

These see the works of the Lord, and his wonders in the deep.

For he commandeth, and raiseth the stormy wind, which lifteth up the waves thereof.

They mount up to heaven, they go down to the depths: their soul is melted because of trouble.

They reel to and fro, and stagger like a drunken man, and are at their wit's end.

Then they cry unto the Lord in their trouble, and he bringeth them out of their distresses.

He maketh the storm a calm, so that the waves thereof are still.

Then they are glad, because they be quiet; so he bringeth them unto their desired haven.

Oh that men would praise the Lord for his goodness, and for his wonderful works to the children of men!

FOURTEENTH LESSON.

You have now proved that the Sun is very useful to us: can you repeat some of the ways in which it is useful?

It gives light and heat.

And what good does the light of the Sun do to us?

It makes all the beautiful colours, and helps us to see them.

And what good does the heat of the Sun do to us?

It warms the earth, and makes the plants grow; and it warms the air, and makes the wind blow; and it warms the water in the rivers and seas, and makes it rise into the air and form clouds.

What good do the clouds do to us?

They fall in rain and water the earth, and make the springs, and brooks, and rivers.

If there were no Sun, would there be any rain or dew?

There would not.

Would there be any brooks and rivers?

Only for a short time.

Why would there not be brooks and rivers?

The springs would soon be dry, and the brooks would run into the rivers, and the rivers into the ocean, and there they would always remain.

Then what would happen to the earth?

The plants and grain would wither and die, and the people would soon die of hunger and thirst.

Who made the glorious Sun to be useful to us?

Our Father in Heaven; and surely we ought to thank Him, for giving the useful and glorious Sun to us.

Did God make the Earth, the Moon, and stars also?

He did. He has made our evenings very beautiful, by setting the Moon and stars in the blue sky.

Has God made anything which you cannot see?

He has made very many things which we cannot see.

Can you tell me of anything God has made, that you cannot see?

He has made a great many worlds that I cannot see.

Why cannot you see them?

Because they are so far above us in the sky.

Then how do you know there are any such worlds, if you have not seen them?

Other people have seen them.

How could they see them?

Through glasses made on purpose.

What are such glasses called?

They are called telescopes.

Can you mention the names of any of the planets that you see in the sky?

We can see Saturn, Jupiter, Venus, and Mars, almost every pleasant evening.

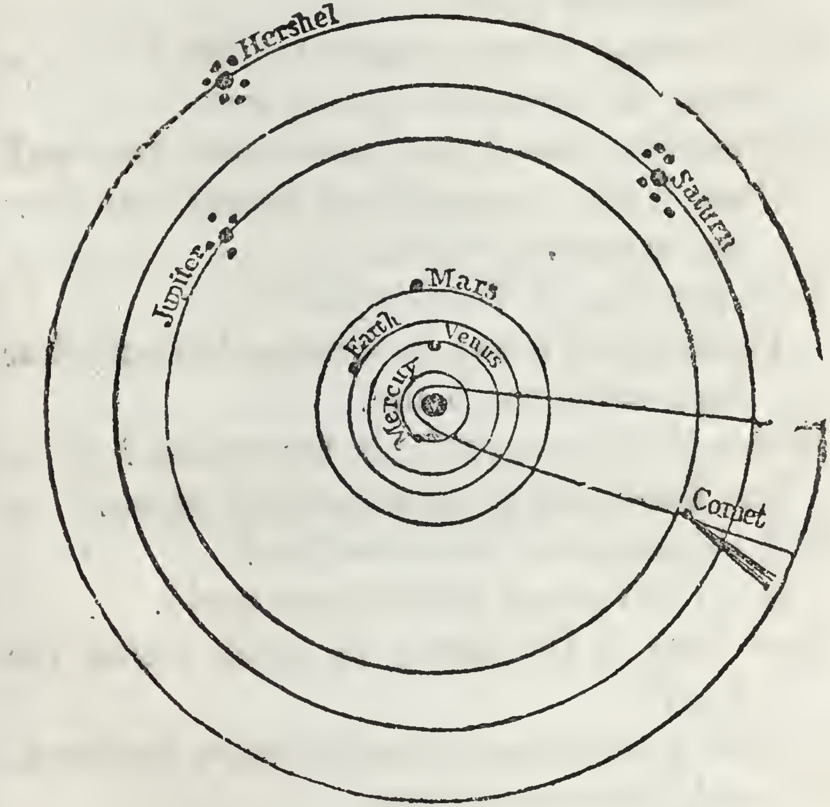
And what other planets can be seen through a telescope?

Mercury, Uranus, and Neptune.

Are these planets like the Earth?

They are, and they are so much like the Earth in many things, that they are supposed to be inhabited.

FIFTEENTH LESSON.



How many large planets are there moving round the Sun?

Eight.

What are their names?

Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus or Herschel, and Neptune.

Which planet is nearest the Sun?

Mercury.

How long is Mercury in moving round the Sun?

Eighty-seven days.

Which planet is next nearest the Sun?

Venus, the beautiful evening star.

In what time does Venus move round the Sun?

Once in two hundred and twenty-four days and seventeen hours.

Then how long is Venus's year?

Venus's year is two hundred and twenty-four days, seventeen hours.

Which is the next planet in the system?

The Earth, and it has a beautiful Moon.

Is it the planet on which we live?

It is; the planet Earth is our world.

How long is the Earth in going round the Sun?

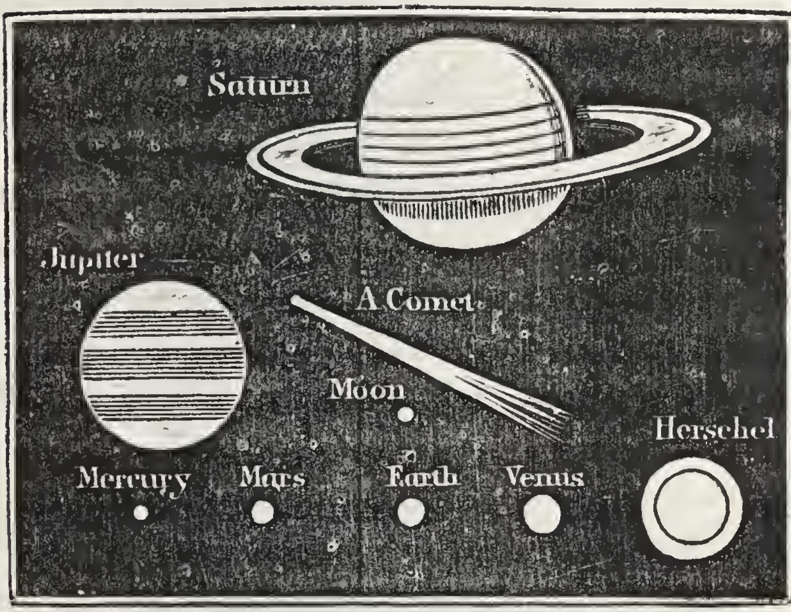
Three hundred and sixty-five days, five hours, and forty-nine minutes.

Then how long is the Earth's *year?*

The Earth's year is three hundred and sixty-five days, five hours, and forty-nine minutes.

What planet is next to the Earth?

Mars.



RELATIVE SIZES OF THE PLANETS.

* Now called Uranus.

How does Mars look?

Mars looks very red and fiery.

How long are the years of Mars?

They are each six hundred and eighty-seven days.

What planet is next to Mars?

Jupiter, a very large and beautiful planet.

Has Jupiter any moon?

Jupiter has four moons.

Do you not think her evenings are very delightful with four moons?

They must be very brilliant.

How long is Jupiter's year?

Nearly twelve of our years, and the days are only ten hours long.

What planet is next to Jupiter?

Saturn.

Do you know anything interesting about Saturn?

Saturn has a broad ring set edgewise around it, and this ring shines like the moon.

What makes it shine?

The Sun shines on one side of the ring almost *fifteen years*, and then on the other side as long.

Has Saturn any moon?

Saturn has *eight moons*, and its evenings must be very bright and pleasant.

How long is Saturn in travelling round the Sun?
Nearly thirty of our years.
What planet is next to Saturn?
The planet Uranus, which used to be called Herschel.
Can you tell why it was called Herschel?
Because Doctor Herschel first saw it through one of his excellent telescopes.
How long is the year of Uranus?
Eighty-four of our years.
How many moons has Uranus?
Uranus has six moons.
What planet is last, and farthest from the Sun?
The planet Neptune.
How long is Neptune's year?
One hundred and sixty-four of our years.
How many moons of his are known?
Only one at present, but he may have more.
Which is the smallest planet?
Mercury is the smallest planet.
Which is the largest?
Jupiter is the largest planet, it is fourteen hundred times as large as the Earth.
Which planets are smaller than the Earth?
Mercury and Venus.
Which planet is nearly as large as the Earth?
Venus.
Which planets are larger than the Earth?
Jupiter, Saturn, Uranus, and Neptune.

SIXTEENTH LESSON.

HAVE any other planets been seen, besides the eight which you have mentioned?

There are *fifty-four small* planets near each other, between Mars and Jupiter.

What are they called?

They are called Asteroids, or star-like bodies.

Are not moons planets?

They are small planets.

By what name are the large planets distinguished from the moons?

The large planets are called primary planets.

What are the moons called?

The moons are called secondary planets.

Why are the large planets called primary planets?

Because they move round the Sun.

Why are the moons called secondary planets?

Because they move round the primary planets.

Is the Earth a primary or secondary planet?

The Earth is a primary planet.

Why is it a primary planet?

Because it moves round the Sun.

Is our Moon a primary or a secondary planet?

The Moon is a secondary planet.

Why is the Moon a secondary planet?

Because it moves round a primary planet.

What primary planet does our Moon move around?

It moves around the Earth.

Do the moons continue moving around their planets, while the planets are going around the sun?

They do; and in this way the moons have two motions.

What are these two motions?

One is their motion around their planets, and the other is their motion with their planets around the sun.

What are the Fixed Stars?

The Fixed Stars are those stars which appear to be fixed in one place, and are not known to move.

How can we tell the fixed stars from the planets?

The fixed stars shine with a twinkling light, and the planets do not.

What are the fixed stars supposed to be?

They are supposed to be suns, like our sun.

Why do they look so small?

Because they are situated at so great a distance from us.

Can all the stars be seen with telescopes?

It is supposed that only a few of them can be seen, even with telescopes.

Why can they not be seen with telescopes?

Many of them are too far off to be seen even with telescopes.

Is it known how many stars there are?

No; for there may be thousands and millions of millions of stars too distant to be seen by us.

What are Comets?

They are bodies which go round the sun like planets.

Do they look like planets?

They do not. They appear to have a long flaming tail on one side.

Do they move around the Sun regularly, like planets?

They do; but in paths so situated that they sometimes approach near the Sun, and afterwards move to a very great distance from it.

Can you tell what the Milky Way looks like?

It *looks* like a very light band in the sky in the evening, a little like a long white cloud.

What is it supposed to be?

It is thought to be a great many millions of *fixed stars* which appear near each other.

Is it not delightful to look at the Milky Way,

and think how many suns and worlds may be comparatively so near together?

It is; and when we think about that wonderful Hand that made them all and put them in their places, it is much more delightful to look at them.

Is it not very proper to call such a great and powerful and wise Being, "Almighty God?"

It is; for none but an Almighty God could do such mighty works.

SEVENTEENTH LESSON.

What causes the water to rise into the air and form clouds?

The Sun warms the water and makes it rise.

What makes the beautiful Rainbow?

The Sun's light passing through the falling drops of water.

But does not God make the clouds and the rainbow?

He does; but he makes use of one thing to make another.

In what way?

He makes the clouds, but he uses the Sun to warm the earth and water first.

Then what does God make use of to form clouds?

He uses the heat of the Sun and the water.

When God uses one or two things to mak another thing, what do we say he does?

We say that God uses means.

Then what means does God employ to make clouds?

The heat of the Sun and water.

In making the rainbow, what does God use?

He uses the light of the Sun and the drops of water.

Can you tell what means God employs to keep the planets in their places, and to make them move around the Sun, without striking against each other?

God has given the Sun the power of drawing the planets to itself.

Then what prevents them from being drawn close to the Sun?

God has given the planets also the power of flying away from the Sun.

What prevents them from flying quite away from the Sun?

The Sun's power of drawing them to itself.

Can you tell what this power of drawing the planets to the Sun is called?

It is called centripetal force.

What is the meaning of centripetal?

Seeking the centre.

And what does force mean?

Power or ability to move.

Then what does *centripetal force* mean?

The power of moving to the centre.

What is the centre to which the planets are drawn?

The Sun.

What do you mean by the *centre* of a body?

The middle point of a body is its centre.

What is the centre of a circle?

A point in the middle of a circle is the centre of the circle.

When the Sun draws the planets to itself, what is it said to do?

We say the Sun *attracts* the planet.

What is meant by Attraction?

Drawing anything.

What is that power called that makes the planets fly from the centre?

It is called centrifugal force.

What is meant by centrifugal?

Flying from the centre.

Then what is meant by *centrifugal force?*

The power of flying *from* the centre.

If the Sun draws or attracts the earth to itself, and the Earth at the same time seems

to try to fly from the Sun, how would the Earth move?

It would move round the Sun, because it could not go *to* the Sun nor go *away* from it, but would continue to move all the time.

Can you give another example?

If I take an apple, and tie a string round it, and then take hold of the other end of the string, and whirl the apple round, it will show how the Earth moves round the Sun.

What represents the Earth?

The apple.

And what represents the Sun?

My hand.

What does the string represent?

It represents the drawing or *attraction* of the Sun.

If you let go the string, what will become of the apple?

It will fly off in a straight line.

What prevents the apple from flying off while you are whirling it?

My hand restrains it by the string, just as the Sun keeps the Earth from flying off.

Why does not the apple fall to your hand, while you are whirling it?

The power that makes it fly off, the centrifugal force, keeps it from falling.

EIGHTEENTH LESSON.

When you were whirling your apple, and it flew off, how far did it go in a straight line?

But a little way before it fell to the ground.

What made it fall?

The Earth, as well as the Sun, has the power of drawing or attracting bodies to itself,—and it attracted the apple.

When the Earth attracts bodies, what is its attraction called?

The Attraction of Gravitation.

What is meant by *attraction* of *gravitation?*

The power which large bodies have of drawing smaller bodies to themselves.

Do *all* large bodies attract smaller ones?

They do.

Then if I leave this book without a support, why does it fall to the floor, instead of falling to the table?

The Earth is so much larger than the table, that the attraction of the Earth is much greater than that of the table.

When I throw a ball into the air, why does it not stay there?

Because the Earth attracts it to itself.

When an apple is broken from the stem, what makes it fall to the ground?

The *attraction* of the Earth.

And what is this attraction of the Earth called?

The *attraction* of *gravitation.*

Then what makes the apple fall to the ground?

The *attraction of gravitation.*

Who found out what makes an apple and every thing else fall to the ground?

Sir Isaac Newton.

Where did he live?

In England.

How came he to find it out?

When he lived in London, there was a terrible disease, called the Plague, raging in the city, and very many people died of it. He went out of the city to escape the plague. One day he was sitting in an orchard, and he saw an apple *fall* from a tree. He then tried to think what *made* it fall. After studying and thinking hard, he at last found out that *great* bodies *attract small* ones. The Earth is larger than anything on it, and of course it *attracts* every thing to *itself.* This is what made the apple fall. Afterwards he found that the Sun was larger than the Earth or the planets, and of course

it draws or *attracts* them all, and this is what makes the planets move round the Sun.

NINETEENTH LESSON.

Did you not say that the Earth attracted every thing that is upon it to itself?

I did.

Why then do we not see the trees and houses fall down to the ground?

Because the small particles of matter of which they consist, possess the power of sticking together.

What is this power called?

Attraction of Cohesion.

What does *cohesion* mean?

Sticking together.

And what is the *attraction* of *gravitation?*

The power which the earth has of drawing bodies to itself.

Do the particles of wood attract each other?

They do.

Do the particles of all other bodies attract each other with equal force?

No; the strength of this kind of attraction is exceedingly different in different bodies.

Can you mention some bodies, whose particles do not attract each other as strongly as the particles of some other bodies do?

The particles of *fruit* do not attract each other as strongly as the particles of *wood*; and the particles of *wood* do not attract each other as strongly as the particles of *iron* and *stone* do.

How can you find out what bodies have the greatest cohesive attraction?

By trying to break them, or to pull them in pieces.

Which has the strongest cohesive attraction, cotton or sponge?

The sponge.

How do you know that it has?

I must pull harder to tear the sponge, than to tear the cotton.

Which has the strongest cohesive attraction, chalk or marble?

The marble.

How do you know that the marble has the strongest cohesive attraction?

Because I can easily crumble the chalk, but I cannot break the marble.

Which has the strongest cohesive attraction, this paper or wood?

Wood has stronger cohesive attraction than paper.

How do you know it has?

I can tear the paper very easily, but I should have to try very hard to break a board or a stick of wood.

Why do you have to try harder to break the wood than to tear the paper.

Because the particles of wood stick closer together than the particles of paper do; the particles of wood have greater cohesive attraction than the particles of paper have.

Can water be made into a table or chair?

It cannot unless it is frozen.

Why can it not?

It would all run away on the ground, because the particles of water *attract* each other only a very little indeed.

Do they attract each other *at all?*

They do.

How do you know they do?

When I dip my finger into water, a drop will stay on the end of my finger.

What makes it stay?

The little *particles* of water *attract* each other, and my finger attracts them too.

Cannot water in some way be made to stand up like wood or stone.

It can be made to stand like wood or stone when it is frozen.

Can you mention anything that has been made of frozen water?

Catherine, the Empress of Russia, had an *ice palace* built for her. It was built of ice instead of wood. Instead of nailing the pieces together, the workmen dashed water on to the places where the pieces were put together; and the water froze them together very hard and strong. When the palace was finished, they made the furniture of ice: ice chairs, and ice tables, ice fire-places, and ice sofas; and a beautiful ice throne. Then they coloured some water green, and some red, and a great many other colours, and froze it, and made beautiful wreaths of flowers around the icy rooms. All was ice within and without the palace. In the evening, when they made fires in their icy fire-places, and lighted the candles in their icy candlesticks; when they hung their icy lamps from the icy walls, and the bright light shone around on the icy furniture, and icy flowers, it was a brilliant scene. The ice was clear and sparkling, like precious

stones, and the palace looked as if it were made of millions of costly diamonds. So we see that water *can* be made into any form, *when the particles attract each other strongly.*

TWENTIETH LESSON.

WHICH, then, has the stronger cohesive attraction, water or ice?

The ice.

Which has the stronger cohesive attraction, water or molasses?

Molasses.

Do the particles of all liquids attract each other equally?

They do not; the particles of some liquids attract each other more strongly than the particles of other liquids do.

How do you know that the attraction of particles of molasses is stronger than the attraction of particles of water?

Because I cannot move my finger through it quite as easily as I can through water.

In which form of butter, solid or melted, is the cohesive attraction stronger?

In the solid butter.

How do you determine that the cohesive attraction is stronger?

It is *hard*, and melted butter is *soft*, running like oil.

Why is *cold* butter harder than *warm* butter?

Because *heat separates* the particles from each other, and *destroys* their *cohesive attraction.*

Which has the *stronger* cohesive attraction, water or steam?

Water has stronger cohesive attraction than steam or vapour has.

Why has it?

Because the force of *heat* has separated the particles of water far from each other, and by increasing their distance, has destroyed the cohesive attraction.

What does *heat* do to *cohesive* attraction?

It partly destroys it.

Which has the stronger cohesive attraction, ice or water?

Ice.

Why has ice stronger cohesive attraction than water?

Because *heat* has partly *destroyed* the cohesive attraction of ice, by melting it, and turning it into water.

Can we destroy the cohesive attraction of lead?

We can by melting it.

How do you know that its cohesive attraction is destroyed?

By pouring it as I do water.

Can you make its cohesive attraction return to it again?

I can by cooling it.

TWENTY-FIRST LESSON.

You have been speaking of the particles of bodies, can you tell what bodies are?

All the things that we see are bodies.

Is the earth a body?

It is a large body.

Are rocks and trees bodies?

They are; and animals are bodies, and we are bodies.

By what other names are *bodies* called?

Matter.

Then is everything that we see, Matter?

It is, and it is called Material.

What properties belong to all bodies?

Impenetrability, extension, figure, divisibility, inertia, and attraction.

What do you mean by *properties* of bodies.

Some things which belong to all bodies, so that there can be no body without them.

What is the first property which you say all bodies possess?

Impenetrability.

If you stick a pin through a paper, is the paper where the pin is?

It is not. The particles of paper are forced or turned aside to make room for the pin.

Why could not the pin and paper be in the same place at the same time?

Because the pin and paper are both *impenetrable*, so that the paper cannot be where the pin is, and the pin cannot be where the paper is.

If you drive a nail into wood, is the wood where the nail is?

It is not; for the particles of wood are moved aside to make room for the nail.

Why could not the wood and nail be in the same place?

Because both the wood and the nail possess *impenetrability*.

If you put a spoon into a glass of water, is the water in the same place where the spoon is?

It is not; the water flows over the spoon, to make a place for the spoon.

Why are not the water and the spoon in the same place?

Because they both possess *impenetrability*, so that where one of them is, the other cannot be at the same time.

If you put an empty vial into water, will the water fill it while it is full of air?

It will not; the air comes out in little bubbles first, and the water runs in as fast as the air comes out.

Why cannot the water and the air be in the vial at the same time?

Because the air and the water have *impenetrability*.

Then what do you mean by *impenetrability?*

Impenetrability is that property which all bodies have of occupying a certain place or space, so that where one body is another cannot be.

TWENTY-SECOND LESSON.

What is the name of the second property which all bodies were stated by you to possess?

Extension.

How far does this book extend?

About five inches one way, and three inches the other.

What do you mean by the extension of this book?

I mean the *length* and *breadth* of the place which this book occupies.

Does it not extend another way?

It does; it is about half an inch in thickness.

Then what is the extension of a book?

Its length, and breadth, and thickness.

What is the extension of a house?

Its *length*, and *breadth*, and *height*.

What is the shape of a ball?

It is round.

Then what is the figure of a ball?

Its figure is round.

What do you mean by the figure of anything?

I mean its shape or form.

What is the figure or shape of a book?

The figure of some books is a square.

What is the figure or shape of the Earth?

Its figure is round, like the shape of a ball.

Have all bodies shape or form?

They have.

And what is the shape or form of a body called?

It is called the figure of a body.

Then what is another property of all bodies?

Figure.

Can you cut this apple?

I can with a knife.

Can you cut one of the pieces again?

I can.

And can you cut one of these little pieces again?

I can; and I can keep doing so until it is cut into very small pieces.

Can a rock be split in two?

It can; and it could be split again and again, until it becomes as fine as sand.

Could a grain of sand be split in two?

It could; and these parts of a grain of sand could be split again and again, as long as they could be seen, if there were anything to split them with.

What is splitting called?

It is called *dividing*.

Then what is another property of all bodies?

Divisibility.

What do you mean by divisibility?

The *property* which bodies possess of being *split* or *divided*.

Could a house be divided?

It could; and a table could be divided; and a book could be divided. Everything could be divided.

Can an apple move itself?

It cannot; it cannot stir from its place, unless somebody moves it.

Can any other body move *itself?*

It cannot, unless it is alive.

Then do we not perceive another property belonging to all bodies?

Yes; the property, not being alive, of remaining at rest if not moved or stirred.

What is this property termed?

Inertia.

Have all bodies any other property?

Yes; Attraction.

What do you mean by Attraction?

The power which massses of matter possess of drawing each other, shown by the power of the Earth to make all bodies approach to itself.

What makes bodies heavy?

The earth draws or attracts them, while we lift them, and we say they are heavy.

Why are some bodies heavier than others?

The more Matter there is in a body, the stronger does the Earth attract it.

TWENTY-THIRD LESSON.

You have been studying some portion of Natural Philosophy; can you tell what is meant by Natural Philosphy?

Natural Philosophy informs us of the properties of bodies, and ascertains the immediate causes of events.

Is the study of Natural Philosophy useful?

It is very useful, and very pleasant likewise.

What does it do to children who learn it?

It explains many things that they did not know before; and knowledge is good for the young as well as for those who are older.

What have you learned in this book, that you did not know before?

I have learned how very useful the sun is, and how the wind and rain are produced.

What have you learned about the planets and stars?

I have learned that the earth and the other planets go round the sun, and that the stars are great worlds and suns.

Can you mention any other things that you have learned?

I have learned the reason why things fall to the ground, instead of going up into the sky.

Who found out what makes things fall to the ground, and what makes the planets go round the sun?

Sir Isaac Newton.

What great Astronomer first saw the planet Uranus?

Doctor Herschel.

Who made all things?

The Bible says, "Thou, Lord, in the beginning hast laid the foundation of the earth, and the heavens are the works of thy hands," and the more we learn about His wonderful works, the more shall we admire His power and goodness.

Do you expect to see all the glorious works of God before you die?

O no! I can only see a very few of them; and no person has ever seen them all.

But can you feel satisfied with seeing so few of his many wonderful works?

I think if I should live a thousand years, and be looking at them all the time, I never should feel satisfied; I should still wish to see more and more of them.

Then what can you do to know more of God?

I can give myself away to Him, and love and obey Him; and then when I die, He will take me to His glorious home, and "I shall be satisfied when I awake with his likeness."

CONTENTS.

SECOND SERIES OF LESSONS

ON

NATURAL PHILOSOPHY.

FIRST LESSON.

WHAT is Natural Philosophy?

Natural Philosophy is the science which ascertains the properties of bodies, and the laws of pressure and motion.

What are bodies?

Everything we see is a *body*.

You have learned something about the Attraction of Cohesion, is it found in all bodies?

It is not.

Is it equal in all?

No; It is stronger in some bodies than it is in others.

In what bodies is it the strongest?

In *hard* bodies.

Do we call hard bodies by any other name?

We call them *solid* bodies, or *solids.*

Can you mention some solid bodies?

Wood, and stone, and iron, are solid bodies.

Are cork and sponge solid bodies?

They are.

But they are soft bodies—are *soft* bodies solid?

They are.

You said hard bodies are solids, how then can soft bodies be solids?

Every body that is not *fluid* is *solid.*

What bodies are fluids?

Water, milk, and oil are called fluids.

How do you know that cork and sponge, and other soft bodies are not fluids?

I can give to sponge and cork any shape I please, and they will retain that shape, but water and other fluids will not.

If I should place a solid and a fluid upon the table, how could you tell which was a solid?

The solid body would remain where you put it.

What would the fluid do?

It would flow on the table, or down from it on the floor.

What do you mean by a fluid ?

Something that *flows*, and will not keep its place, unless it be confined in a vessel.

Do all fluids flow like water or oil ?

Not all; there are some fluids that are different from water or oil.

Then how many kinds of bodies are there ?

Two.

What are their names ?

Solids and Fluids.

Why are some solids *hard*, and other solids *soft ?*

Because the attraction of cohesion is stronger among their particles than among those which are soft.

What do you mean by the Attraction of Cohesion ?

The Attraction of Cohesion is the power of sticking together which is given to the particles of bodies.

What do we call hard solid bodies ?

We call them *dense* bodies.

What bodies are dense ?

Those bodies are dense whose particles are close together. Iron is very dense, and so is wood.

Which has the greater density, the iron or the wood ?

Iron has the greater density.

Why has iron greater density than wood ?

Because its particles are closer together than the particles of wood are.

How do you know that they are?

It does not require so much strength to cut wood, as it does to cut iron.

What do we call soft solid bodies?

We call them *rare* bodies.

What bodies are rare?

Those bodies are rare, whose particles are not very close to each other. Cork and sponge are rare bodies.

Which body has the greater rarity, cork or sponge?

Sponge is the more rare.

Why is sponge more rare than cork?

Because its particles are so arranged, as to leave many small spaces in the mass.

How do you know this?

Because sponge is more easily divided than cork.

When you say the fog is very dense, what do you mean?

I mean the fog is very thick, and its particles are so very near each other, that we cannot see through them.

Is steam a solid or a fluid?

Steam is a fluid.

How do you know?

Because it does not keep its place, and it cannot be made into any shape.

Can the air be made into any shape or figure?

It cannot.

Then is the air a solid or a fluid?

The air is a fluid.

Does the air flow to the ground like water?

It does not.

Why does it not, if it is a fluid?

It is resisted by the air that surrounds it.

Where is the Air?

It is all around us. It is what we breathe.

Then we can breathe a fluid, can we not?

We can: and after breathing, the air remains chiefly fluid.

But is air such a fluid as water?

No; it is a different kind of fluid.

What is the name given to such fluids as water and oil?

They are called *liquids* or *running fluids*.

What is the name of such fluids as air and the vapour of water?

They are called *aëriform* fluids,

What is the meaning of aëriform?

Aëriform means in the *form of air*.

Why are these fluids called aëriform?

Because they are like air.

SECOND LESSON.

If you throw an India-rubber ball upon the floor, will it lie there?

It will not; it will instantly bound from the floor.

What makes it bound up?

It is distended with air, and the air makes it rebound.

Would it rebound if it were filled with other things?

It would, but not so high as it does when full of air.

Will you tell me how the air can do this?

When I throw down the ball, the side that touches the floor is flattened or pressed inwards, and does not leave as much room for the air within it.

What becomes of the air in it then?

The particles of air are pressed together, so that they do not take up as much room as they did before.

What presses them together so closely?

The striking together of the ball and the floor, when you throw the ball upon the floor.

How long will the air in the ball continue to occupy the diminished space?

Not a moment.

What will it do?

It will instantly spring back, and press out the flat side of the ball, making it as round as it was before.

What will the ball do then?

It will bound up from the floor.

What is the springing of the air called?

It is called *elasticity.*

When we say the air has the power of springing back, what do we mean to say?

We mean to say that the air is *elastic.*

What other bodies are elastic?

Every body that springs back to its first shape, when it has been pressed in or struck, is an elastic body.

Can you mention some bodies that are elastic?

Ivory, wood, and many other hard bodies are elastic.

What bodies are not elastic?

Clay and wax are not elastic.

How can you tell whether a body is elastic?

By striking it against another body.

What will it do if it is elastic?

It will bound back without seeming to be flattened or bent inward.

How will it be if it is not elastic?

It will not bound back again, but will remain flattened.

How do you know that the air is elastic?

If the air *in* the ball is elastic, the air *out* of the ball must be elastic too.

When you stretch a piece of India-rubber, what makes it spring back as soon as you let it go?

Its elasticity.

If you pull out the string of a bow, what will happen to the bow?

It will bend.

What if you let go the string?

The bow will straighten as it was before.

Why will it straighten?

Because the wood of which the bow is made is elastic.

Why do you pull the string hard when you fix the arrow to it?

So that the arrow may fly the farther.

What makes the arrow fly off when you let go the string?

The bow is bent when I put on the arrow, and the moment I let go the string, the bow springs back so quickly, that it straightens the string with a jerk, and the arrow is sent into the air.

Now can you tell me what it is that makes the arrow fly off from the bow?

It is the elasticity of the bow.

You said the air is a fluid—then are fluids elastic?

Some fluids are.

What fluids are elastic?

Aëriform fluids are called elastic fluids.

THIRD LESSON.

When you say a body is *moving*, what do you mean?

I mean that the body is *changing its place*.

Then what is the meaning of the word *motion?*

Motion means change of place.

When your ball moves along the floor, what *puts* it in motion?

My hand.

When the arrow flew through the air, what put it in motion?

The elasticity of the bow.

Then what puts bodies in motion?

The *power* of the body that strikes them, or draws them, puts them in motion.

What is this power called?

It is called *force.*

What puts the arrow in motion?

The force of the elasticity of the bow.

How do you know?

If the bow had not been elastic, the arrow never would have left the string.

When a body is moving, why does it, after a certain time, stop?

Another power or force opposing, makes it stop.

What causes an arrow to cease to move upwards, after it has been driven in that direction?

The attraction of the earth gradually destroys the motion upwards, and then draws it down again.

If the arrow strike a tree or board, what is the force which then stops it?

The force with which the particles of wood cohere.

How does this force, cohesive attraction, stop the arrow?

It keeps the particles of wood so closely together, that the arrow cannot separate them.

When the wood will not permit the arrow to go through it, what do we say the wood does?

We say the wood *resists* the arrow.

Is the arrow resisted by the particles of wood, or by the attraction of cohesion that binds the particles together?

By the attraction of cohesion.

How do you know?

When the cohesion of the particles of the wood has been destroyed, the arrow must pass through with facility.

When a ball is thrown upwards, will it move all the time of its ascent as fast as it did when it first left the hand which threw it?

It will not, but will move slower and slower until it stops, and begins to descend or move in the contrary direction.

When the motion of a body becomes slower and slower, what do we call such motion?

We call it *retarded* motion.

What is the meaning of *retarded?*

Retarded means motion gradually becoming slower.

If you were running, how could you *retard* your motion?

By beginning to walk.

If you were walking, and should begin to run, and should continue to run faster and faster, what kind of motion would that be?

It would be *accelerated* motion.

What do you mean by accelerated motion?

Quickened motion.

If you were walking, and should not at any time go faster or slower, what motion would that be?

It would be *uniform* motion.

What is meant by *uniform* motion?

Motion that is always alike, never slower or faster.

What bodies always move with equal velocity?

The hands of a watch, and all the wheels in a watch, move just as fast at one time as they do at another.

Then what is the motion of a watch?

It is uniform motion.

When a ball is falling to the ground, what is its motion?

It is accelerated motion.

Why is it accelerated?

Bacause the attraction of the earth acts during the whole descent of the body, and therefore continually adds motion to that already acquired.

When you throw up a ball, what is its motion?

It is retarded motion.

Why is it retarded motion?

Because the earth draws it downwards from the instant it leaves my hand, to the time when it stops and begins to return to the ground.

How many kinds of motion have you mentioned?

Three.

What are they called?

Retarded motion, *accelerated* motion, and *uniform* motion.

How does a body move when its motion is retarded?

Slower and slower.

How, when its motion is accelerated?

Faster and faster.

How, when its motion is uniform?

Neither faster nor slower, but always alike.

When you say a ball *ascends*, what do you mean?

I mean that the ball goes upwards from the earth, or rises.

When a body *descends*, what does it do?

It drops downwards towards the earth, or falls.

What kind of motion has a body when it ascends?

Retarded motion, because it rises slower and slower.

What is the motion of a body when it *descends?*

Accelerated motion, because it falls quicker and quicker.

What is the motion of water when it is falling in a cataract?

It is accelerated motion.

FOURTH LESSON.

WHEN you throw a ball against the wall, what happens to the ball?

It flies back, as if the wall threw it back to me.

What is its motion from the wall back to you called?

It is called *reflected* motion.

What is meant by reflected motion?

The motion made by *throwing back* anything.

What is the meaning of the word reflect?

It means to *throw back* again.

Then when I say a body is reflected, what do I mean?

You mean that the body is *thrown back* again.

If I should strike a ball to make it go one way, and you should strike it to make it go another way, if it afterwards move at all, what would its motion be called?

It would be called *compound* motion.

Why would it be called compound motion?

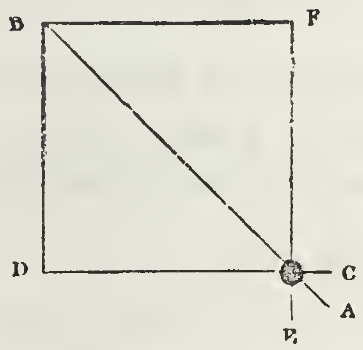
Because it would be two motions put together.

What two motions would it be?

The motion which your hand gave it, and the motion which my hand gave it at the same time.

Which way would the ball move, if we struck it together?

It would not go the way your hand sent it, nor the way my hand sent it, but it would move betwixt the lines of the two forces. It would move in the line A B, lying betwixt C D and E F in the direction of the two force



When you hold at one end a string, which is tied to a ball at the other, and swing the ball round, what is the motion of the ball?

It is *circular* motion.

Why is it called circular motion?

Because the ball moves round in a circle.

What is the motion of the Earth round the Sun called?

It is called circular motion.

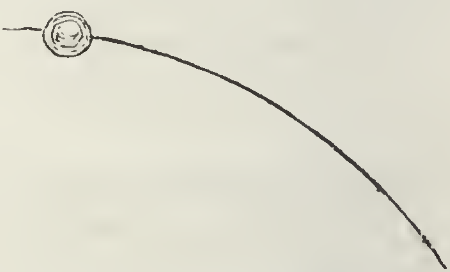
Why?

Because the Earth moves in a circle around the Sun.

Here is a diagram which shows you what circular motion is.

If you throw your ball forward, will it fall down to the ground in a *straight* line?

No; it will make a curved line, like the diagram.



What is the motion of the ball then called?

It is called *curvilinear* motion.

What is the meaning of curvilinear?

Curved line.

Then what is curvilinear motion?

Motion in a curved line.

What makes the ball move in a curved line?

My hand sends it straight forward, and the attraction of the earth draws it straight down.

Then which way will the ball move?

It cannot go either way, but goes between them.

Then is curvilinear motion compound motion?

It is.

Why?

Because it is the motion made by my hand, and the attraction of gravitation together.

Is circular motion compound motion also?

It is.

Why?

Because it is made by throwing the ball into the air, while, at the same time, you keep it from going off, by holding the string.

How is the circular motion of the earth compound motion too?

The centrifugal force makes it go from the centre. and the centripetal force draws it to the centre.

To what centre?

The sun, because the earth moves round the sun.

FIFTH LESSON.

When a pendulum of a clock moves backwards and forwards, does the ball move in a straight line?

It does not; it describes part of a circle.

Why does it not swing quite around the place where it is fastened, just as the ball does when you whirl it round your hand?

The attraction of gravitation draws the pendulum down towards the ground when it begins to go up.

Then why does not the pendulum stop, instead of going up the other side?

Because it goes down so fast that it cannot stop in an instant.

What is this like?

Like a boy sliding down a hill, with another hill at its foot.

How does he go?

He goes so fast down the hill, that when he gets to the bottom he cannot stop, but goes partly up the adjoining hill before he stops.

How would it be if somebody should push him down this second hill?

He would go part of the way again up the first.

And how is this like the pendulum?

When I let go the pedulum in the position of the figure, it will descend as low as possible, and with the velocity it has acquired will again ascend.

What will then occur?

The attraction of the earth will again cause it to descend, and rise again towards the point from which it started.

How long will it move thus?

nly a very short time.

Could it not be made to go for ever without stopping?

It could not.

Why could it not?

Because the attraction of the earth and the resistance of the air would finally make it stop.

How do the Russians obtain their favourite amusement of sliding down a hill?

They have an artificial mountain of ice.

Can you tell how it is made?

A wooden mountain is first constructed, having three hills, one above the other, with a valley between each hill.

How do they get to the top of it?

They walk up one hill, then down into the little valley, then up a higher hill, and down into another valley, and then up to the top of the mountain.

How do they amuse themselves on this mountain?

There are three roads down the mountain, and at the top of one of these roads is a little carriage, just big enough to carry one person down the hill. As soon as the carriage is set in motion, it goes down the first hill very swiftly indeed.

Will it then stop?

It cannot stop.

Why cannot it stop?

Because it descended the hill so fast, that it must slide across the little valley, and ascend the next hill.

When a pendulum continues, how is the motion produced?

By the wheels of the clock to which it is attached.

What makes the wheels move?

The weights suspended to the cord wound round the barrel, on the axis of the first wheel.

How long will the pendulum swing before it stops?

As long as the wheels move.

How long will the wheels move?

Until the cord is drawn off the barrel.

How can they be put in motion again?

By winding the cord again round the barrel, and thus raising the weights.

What makes the weights go down to the bottom of the clock?

The attraction of the earth.

Then when a clock goes, what does the attraction of the earth do to make it go?

It keeps the wheels in motion, and the pendulum swinging.

How fast does a pendulum commonly swing backwards and forwards?

Once in every second, or sixty times in a minute.

Can anything be made to move for ever without stopping?

No; nothing.

Has any one ever tried to make a body move for ever?

Yes, many have tried, but they could not do it.

Why can it not be done?

Because the attraction of the earth is so great that it will always stop the motion at last.

If a body should move for ever, what would its motion be called?

Perpetual motion.

What is the meaning of perpetual?

Perpetual means never-ending.

Then what is perpetual motion?

Never-ending motion.

How many kinds of motion have you learned to distinguish?

Eight.

What is the first?

Retarded motion, or motion that becomes slower and slower.

What is the second?

Accelerated motion, or motion that becomes faster and faster.

The third?

Uniform motion, or motion that is always alike.

The fourth?

Reflected motion, or moving back again.

The fifth?

Compound motion, or two motions together.

The sixth?

Circular motion, or motion in a circle.

The seventh?

Curvilinear motion, or motion in a curved line.

The eighth?

Perpetual motion, or motion that will never stop.

SIXTH LESSON.

How do children play at *see-saw?*

They take a plank of wood, and lay it across a block or a fence, and then one sits on each end, and they alternately rise and descend.

What is the plank sometimes called?

It is called a *lever*.

What is a lever?

A rod or plank that will not bend is a lever.

What is the block that it rests upon called?

It is called a *fulcrum*.

What is a fulcrum?

That which supports the lever or plank, when its ends move up and down.

If the plank were laid across a fence, when you play see-saw, what would be its fulcrum?

That part of the fence that it lies across.

What are the parts of the lever on each side of the fulcrum called?

They are called *arms* of the lever.

Then if you were playing at see-saw, where would the arms of the lever be?

I should sit on one arm of the lever, and my companion would sit on the other arm.

If you are just as heavy as your companion, where must the block or the fulcrum of the plank be placed?

Exactly in the middle, so that one arm may be just as long as the other.

Then if you sat still upon the plank would it move up and down?

Each arm would exactly balance the other, and it would stand still.

When do bodies balance each other?

When one is just as heavy as the other.

If your companion were twice as heavy as you are, how must the plank be placed on the fulcrum?

So that the arm on which I sit may be twice as long as his.

Where would the fulcrum be then?

Near my companion.

What *power* sets the lever in motion?

We are the power; because I strike my feet on the ground so as to send myself up, and that makes

my companion go down, and then he does the same, and goes up while I go down.

If a stone much heavier than yourself should be placed on one arm of the lever, how could you raise up the stone?

By putting the fulcrum so near it, that the arm on which the stone lies would be very short, and the other arm very long.

Would you have to use much strength to raise it then?

I should not if the long arm was very heavy.

Why would you not?

Because the long arm would be so heavy that it would by its weight almost raise the stone on the other arm.

Then what is the use of the lever?

It assists us in raising large and heavy bodies.

In raising the stone what was the power?

My hand.

What the weight?

The stone.

What the fulcrum?

The block upon which the lever rested, or rather the resistance.

Where was the fulcrum placed?

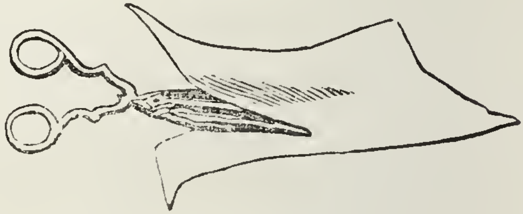
Between the power and the weight, or between the hand and the stone.

Is a pair of scissors like a lever?

Yes; it consists of two levers slightly fixed together at the fulcrum?

Do both levers move the same way?

No: when one moves up, the other goes down till they meet together.



Has each lever the same fulcrum?

Yes.

How are the levers placed, and what is their fulcrum?

Each lies across the other, and they are fastened together where they cross by a small rivet or screw that goes through them.

Then what is the true fulcrum of the scissors?

The rivet that fastens the scissors together.

What is the power that moves these levers?

My fingers.

What is the resistance opposed to my fingers?

If I am cutting paper, the paper is the resistance.

Will you tell me why the paper is the resistance?

Because when I am cutting it, I lift the paper up

with the lever which my thumb draws down, and press down the paper with the lever which my fingers draw up.

How will this cut the paper?

The levers are screwed so tight to each other, that when they come together there is no room for the paper between them.

What becomes of the paper then?

One part of the paper remains on one side of the scissors, and the other part is on the other side, and the scissors are between them.

Then what have the scissors done to the paper?

They have *divided* it.

Are the scissors the same kind of lever as the see-saw?

They are.

Why are they so considered?

Because in each, power is applied at one end, and the resistance at the other; the fulcrum being between them.

When a grocer weighs out a pound of sugar, how does he proceed?

He takes a pair of scales or balances, like this in the picture, and puts a piece of metal that weighs exactly a pound into one of the scales.

Then what does he do with the sugar?

He puts just as much sugar into the other scale as will lift up the weight in the first scale.

How can he tell when he has put in a pound of sugar?

When one scale is just as heavy as the other then the sugar is weighed right.

Are these scales like a lever?

Yes, they are a lever.

Which is the fulcrum?

The place where they are hung up is the fulcrum.

What is the weight.

The sugar is the weight.

What is the power that raises the sugar?

The lead in the other scale.

Then is not the lever very useful?

It is; it would be very difficult for us to do many things without the lever.

SEVENTH LESSON.

When you open a door, which is the weight that you move?

The door is the weight.

What is the fulcrum?

The hinges are the fulcrum.

What is the power?

My hand.

Is the door such a kind of lever as the see-saw?

It is not.

Why is it not.

Because the weight is between the power and the fulcrum.

How is it with the see-saw?

The fulcrum is between the power and the weight.

Is there any other kind of lever?

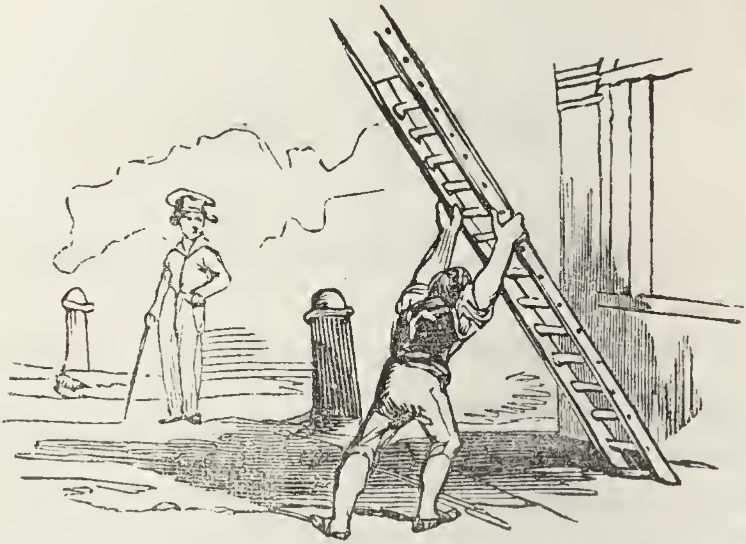
There is one more.

What is it?

It is a lever which has the power between the weight and the fulcrum.

Have you ever seen such a lever?

Yes; when I have seen a man raising a ladder against the wall.



What was the fulcrum?

The ground on which the bottom of the ladder rests.

What the weight?

The ladder.

What was the power?

The strength of his hands.

Then how many kinds of levers are there?

Three kinds.

What is the first?

One where the fulcrum is between the power and the weight—as the see-saw.

What is the second?

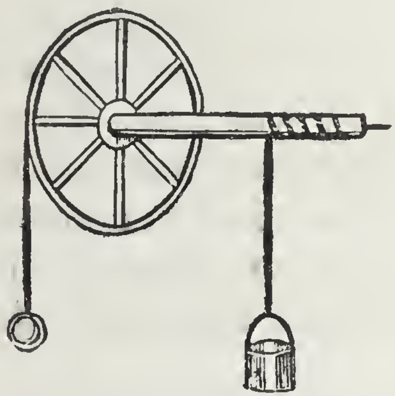
One where the weight is between the power and the fulcrum—as the door.

What the third?

Where the power is between the fulcrum and the weight—as a man raising a ladder.

What other mode of raising weights is there besides the lever?

The wheel and axle.



What is the shape of a wheel?

It is round like a hoop, with sticks called spokes going from the centre to the outside or rim.

What is the axle of a wheel?

The piece of wood into which the spokes are fastened, and on the extremities of which the wheel rests.

What is the use of a wheel and axle?

It is used to raise weights.

Have you ever seen a wheel and axle used in raising a weight?

Some wells have a wheel and axle to raise up the bucket of water out of them.

How is it done?

The rope or chain on which the bucket hangs is fastened to the axle, and when the axle is turned round by the handle, which answers the purpose of a wheel, the rope is wound round the axle till the bucket comes up.

Can you tell how a wheel and axle is like a lever?

The spokes are the long arms of the lever, and the radius of the axle forms the short arms.

Why will a ball roll down an inclined plane, as a desk, if placed at the highest part of it?

Because the desk not being level, the ball is not supported.

What may a desk then be called?

An *inclined plane*.

What is a plane?

A smooth surface.

What is an *inclined plane?*

A smooth surface that is not level.

What is the use of an inclined plane?

It is used to raise weights.

How is a weight raised easier by an inclined plane than without it?

If we put one end of a long board upon a waggon, and let the other rest upon the ground, and roll

a barrel up the board into the waggon we shall find it much easier than it would be to lift it straight up from the ground into the waggon.

EIGHTH LESSON.

WHAT is the shape of the blade of a knife?

It is like two inclined planes put together.

What would the blade of a knife be called in Mechanics?

It would be called a *wedge*.

What is a *wedge ?*

It is like two inclined planes put together, so as to have a sharp edge on one side, where they meet.

Of what use is a wedge ?

To cut or divide anything, or to overcome pressure.

Mention the names of some wedges.

A knife is a wedge, and so is an axe, and almost all cutting instruments are wedges.

Have you ever seen a screw ?

Very often.

Where have you seen it ?

The blades of a pair of scissors are kept together by a little screw, and hinges and locks are fastened upon doors with screws.

Why are not nails as good as screws to fasten them with?

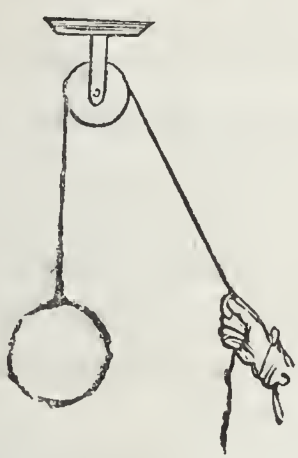
A nail may be pulled out; but the thread or spiral edge of the screw keeps it in its first position, and it remains firm.

What is a screw like?

It is much like a round nail, with a sharp wedge wound round it.

Of what use is the sharp edge or wedge around the screw?

It cuts the wood as it enters, when turned by the screw-driver; and by its extensive friction preserves a firm hold of the wood.



What is a *pulley?*

A pulley is a little wheel, with its edge hollowed out, so as to make a place for a cord to wind around it.

Of what use is a pulley?

Weights are raised by means of pulleys, and removed to other places.

How do they help people to raise weights?

The weight is fastened to one end of the cord, and a person can raise the weight by pulling down the other end of the cord.

How are buckets of water sometimes raised out of a well?

A rope is put over a large pulley, a good way above the top of the well, and the bucket is fastened to one end of it, and a large stone to the other.

How is an empty bucket drawn down into the well?

We pull down that end of the rope on which the bucket hangs, and the stone on the other end rises.

Then, what do you do?

When the bucket is filled with water, we can raise it with very little exertion, because the stone on the other end is so heavy that it almost lifts up the bucket itself.

How many kinds of pulleys are there?

Two; the *fixed* pulley, and the *moveable* pulley.

What is a fixed pulley?

A pulley that does *not* ascend or descend as the weight moves.

What is a moveable pulley?

A pulley that *does* ascend or descend as the weight is moved.

Which is the more powerful?

The moveable pulley; for the pulley which is fixed serves merely to alter the direction of the power.

NINTH LESSON.

What are the lever, wheel and axle, pulley, inclined plane, wedge, and screw, called in Mechanical Philosophy?

They are called *mechanical powers.*

What do you mean by mechanical powers?

The power of machines or instruments.

Of what use are the mechanical powers?

They help us to raise and move very large weights, and to divide and cut hard bodies into any shape we please.

Can you mention some useful machines or instruments?

Coffee-mills, clocks and watches, and steam-boats are useful machines.

Of what use are steam-boats?

They carry very heavy loads of goods and people along the water much faster, and with greater certainty than other vessels can.

How can they do this?

By means of the power of the machinery in them.

What gives motion to the machinery?

The power of the steam produced in the boilers.

How can the carriages on railroads be made to move so very rapidly?

It is by means of the power of steam in suitable engines.

Does steam keep these carriages in motion?

It does. Other carriages are kept in motion by horses.

What is the meaning of machine or machinery?

When several instruments or mechanical powers are put together, we call the whole a machine or machinery.

What did you say keeps the machinery of steam-boats in motion?

The steam from the boilers.

What is steam called when it moves machinery?

It is called a *moving power*.

Then what is the moving power of steam-boats?

Steam.

What is the moving power of railroad carriages?

Steam and horses.

What is the moving power of a clock?

A weight or a spring.

How do you know?

I see the weight or the spring that turns the wheels, and keeps the clock in motion.

In mills and manufactories placed upon the banks of rivers, what is the moving power?

The water.

How do you know?

It is the water running against the great wheels that keeps them turning; when the stream is very low, or almost dry, the wheels stop.

Is water the moving power of all mills?

No; wind is the moving power of some mills.

What are such mills called?

Windmills.

When animals or men move machines, what do we say the moving power of such machines or instruments is?

Animal power. The muscular energy of men and animals, is the moving power; and occasionally their simple weight, is the moving power.

Who has provided the moving powers of all machines?

The Creator of the world?

What good have they done for man?

They have saved him from the performance of much hard labour.

How have they done this?

It would require all the strength of a great many men to lift, and carry, and cut a great many heavy and hard bodies, which one man can do alone with a machine.

Can you mention one example?

In cotton factories, where cotton cloth is made, they have machines to card and spin, and weave; so that a very few persons can make hundreds or thousands of yards of cloth in a day, from cotton that is brought in that morning.

Can you mention another example?

On railroads a little steam-engine can draw a great many heavy-loaded carriages thirty miles in one hour.

Who teaches man how to save his labour by contriving these machines?

Our Creator.

How does he teach us?

He made the wood and iron of which machines are formed; and the wind and water, and strength that moves them; and the mind in us that thinks and contrives how to use those things.

Can you describe a machine so curious that it could never have been made without a great deal of thinking and contriving?

A man in England made two clocks, and sold them to some gentleman, who sent them as a present to the Emperor of China. Each clock was in the shape of a little chariot. A very small lady sits gracefully in it. Her right hand is leaning upon the chariot. Under her hand is a curious little *clock*, about as large as a shilling. This clock strikes every hour, and will go eight days without being wound up. Upon the lady's finger sits a beautiful little *bird*, adorned with diamonds and rubies. Its tiny wings are spread out ready to fly, and if a diamond button below it be touched, the bird will flutter for some time.

What makes the bird move?

Its little body is full of very small wheels, which make it move.

How large is the whole body of the bird?

About the size of a pea.

Can you tell anything more about the clock-chariot?

The lady holds in her left hand a gold tube, not larger than a large pin. On the top of this tube is a small round box. Around this box is a ring made with gold and diamonds, not larger

than a sixpence. This ring goes round and round the box, three hours at a time, without stopping.

Can you tell what is over the lady's head?

There are two small *umbrellas*, standing upon a pillar no larger than a quill. Under the largest umbrella is a little *bell* which strikes every hour. At the lady's feet is a golden *dog*, and before it are two little *birds* fastened upon springs. Their wings and feathers are very brilliant with precious stones, and they seem to be flying away with the chariot.

How can the chariot move along?

By means of springs and wheels that are concealed. If they are touched they can make the chariot go straight forward, or in a circle, or in any way that you wish.

What is behind the chariot?

A little golden *boy* taking hold of it, and seeming to push it along. Above the umbrella are *flowers* and *ornaments* of precious stones; and at the top of the whole, stands a little *flying dragon*, made of the same brilliant stones.

What useful knowledge may we obtain from this curious description?

That the man who made these wonderful clocks had great skill; and that God who made the

man, and gave him so much skill, must be more skilful than all the men in the world—*more skilful far than we have power to comprehend.*

TENTH LESSON.

If you leave your book without support, what will happen?

It will fall to the ground.

Why does it move towards the ground?

It is attracted by the earth.

By what term is this attraction signified?

It is called the attraction of gravitation, or simply, gravitation.

Does this power show itself everywhere, when bodies have nothing to hold them up?

It does.

What kind of power do we call the power of gravitation?

A *natural* power.

What do you mean by natural power?

A power that God has given to bodies, and that man cannot make.

Is there any other power besides natural power?

Yes; there is *mechanical* power.

What kind of power is mechanical power?

The power that machines have—such as pulleys, levers, and wheels.

If a stream of water run under a wheel properly constructed, and slightly immersed in it, what will be the effect?

The wheel will turn round upon its axis.

What then makes the wheel turn?

The water; which, as it runs, strikes the portion of the wheel dipped in it.

Does *man* give this power to running water?

He does not. God gives it.

Then is the power of running water, a *natural*, or a *mechanical* power?

It is a *natural* power.

When the wind blows against the vanes of a wind-mill, what does the axle do?

It turns round very fast.

What makes it turn?

The power of the wind.

What is wind?

Wind is moving air.

Is the power of moving air made by man?

It is not. God made it.

Then is moving air a natural or a mechanical power?

It is a natural power.

When you throw a ball, what becomes of ?

It moves on in the direction in which I throw it.

What makes the ball move on?

The power of my arm.

Do you make this power?

I do not. God makes it.

What do you call this power that God has given to men and animals.

We call it animal strength.

Then is animal strength a natural or a mechanical power?

It is a natural power.

What other name is given to power?

Power is sometimes called *force.*

Then how many natural forces are there?

Four.

What are they?

Gravitation, or the *weight of solid bodies*—the force of *flowing water*—the force of *moving air,* and *animal strength.*

Could men make machines without these *natural* forces?

They could not.

Which of the natural forces assists men in all machines?

Gravitation.

Which natural force helps men in their mills and factories?

The force of flowing water.

Can there be mechanical power without natural power?

There cannot.

How do you know there cannot?

Because all machines have weight, or something that draws them down to the earth, and many have the power of running water to help them to move.

Can there be natural power without mechanical power?

There can.

How do you know?

There is no mechanical power required to cause an apple, when unsupported by the tree, to fall to the ground: gravitation is sufficient. A current of water will carry a boat along, and sometimes tear up trees, and roll rocks over a cataract without any help.

Do all animals possess the same strength?

No; some are very weak, like the lamb; and others are strong, like the lion.

Are all men equally strong?

No; some men have ten times more strength than others.

Can you mention the name of a very strong man?

Sampson, whose story is in the Bible was the strongest man that ever lived.

What wonderful thing did he do by his strength?

He was carried by his enemies, the Philistines, into the house of their god, that the people might make sport of him, because his eyes were put out. The house was full of men and women. It was so very large, there were upon the roof about *three thousand* men and women that beheld, while Sampson made sport.

"And Sampson called unto the Lord, and said, O Lord God, strengthen me, I pray thee, only this once, O God, that I may be at once avenged of the Philistines for my two eyes.

"And Sampson took hold of the two middle pillars upon which the house stood, and on which it was borne up, of one with his right hand, and of the other with his left.

"And Sampson said, let me die with the Philistines. And he bowed himself with all his might, and the house fell upon all the people that were in it."

Do common men ever show very great strength?

They often do.

Can you mention any such men?

The men who carry travellers up the mountains in Peru, show very great strength.

How do they show it?

They will carry loads that weigh two hundred pounds during eight or nine hours a day, up the mountains.

What are these men called?

Cargueros, or carriers.

Which has the greater weight, a cannon ball or a bullet?

A cannon ball.

If you throw a cannon ball against a thin board, will it go through the board?

It will not.

If a bullet be shot out of a gun, will it go through the board?

It will.

Why does the bullet go through, when the cannon ball, which is much heavier, does not?

Because the bullet goes so much faster than the ball.

What is swift motion called?

Velocity.

Then why will the bullet go through the board, when the ball will not?

Because the weight and *velocity* of the bullet together, are greater than the weight and velocity of the ball combined.

When weight and velocity are combined, what is the whole effect called?

The *momentum* of the body.

Which is greater, then, the momentum of a cannon ball thrown by the hand, or that of a bullet fired from a gun?

That of the bullet.

How could you increase the momentum of the cannon ball?

By firing it from a cannon.

ELEVENTH LESSON.

Will a sledge descend more easily down a hill of sand or a hill of ice?

Down a hill of ice.

Why will it descend more easily down the hill of ice?

Because ice is much smoother than sand.

Then is the want of smoothness or the roughness of the sand, the impediment to the sledge in descending upon it?

It is.

What term do philosophers apply to the effect of this roughness upon bodies moving or rubbing against each other?

The term *friction*.

Which can you move more easily, the bolt of a rusty lock, or one which is well polished?

The polished bolt.

Then which lock has the more *friction?*

The rusty one.

Why does a person slip down when on ice, and not when on stone or earth?

Because there is more friction when his feet rub against the stone or earth than when they rub against the ice.

How could the rusty lock be made to move as easily as a bright one?

By oiling it.

Why would oiling it make it move easily?

It would take away some of the friction.

How would it take away the friction?

By making the iron smooth.

Can you mention another example of friction?

I have heard carriage-wheels creak, because they wanted greasing.

Why do people grease carriage-wheels?

To make them smooth and turn easily.

Why will the grease make them turn easily?

It destroys some of the friction made by the rust and rough iron.

Why do drivers of carriages, when going down steep hills, fasten one of the wheels, so that it cannot turn?

To increase the friction of the wheel, and prevent the carriage from going down so fast.

What does increasing the friction mean?

Making part of the circumference of the wheel rub strongly against the surface of the road.

How many kinds of friction are there?

Two.

What are they called?

The *dragging* and the *rolling* friction.

Can you mention an example of dragging friction?

The chained wheel *dragged* down the hill.

What is an example of *rolling* friction?

Wheels when they are turning or rolling.

When the walks are covered with ice, why is it difficult to walk upon them without slipping?

Because there is not friction enough.

What would happen to us if there were no friction?

We could not walk a step before we should begin to slip along very fast, and could not stop ourselves.

How do people increase the friction when the walks are covered with ice?

They throw sand or ashes, or something rough upon them; or cover the soles of their shoes with something which is rough.

Could you hold anything in your hand if there were no friction?

Not without difficulty.

Why?

Because it would slip through so easily.

Then is not friction very useful?

It is; for I could not hold my knife and fork, or book, very easily, without friction.

How do people travel from Mount Cenis, in Europe, to the town of Laneburg?

On the top of the steep snowy precipice, the traveller gets into a sledge, and slides down so swiftly that he goes three miles in seven or eight minutes, and his breath is almost taken away from him by the motion.

What makes him go down so fast?

The ice is so smooth that there is scarcely any friction whilst the sledge glides over it.

Why is it much easier to travel and to carry heavy loads upon snow, than upon the ground?

Because the snow is so very smooth, that the friction is almost destroyed, and the runners slide along more easily than wheels roll along the ground.

Why would not wheels go as well upon snow and ice, as the runners of sledges?

Because the wheels would sometimes roll and

sometimes slide along, and the horse would find it difficult to draw the carriage steadily and safely.

TWELFTH LESSON.

Do you recollect what you learned about springs?

I learned that they were made by the water under ground bursting out at the surface, when it could go no farther under ground.

When water thus flows for a short time, and then stops, and then flows again, and continues stopping and flowing, what is the spring called?

It is called an *intermitting* spring.

What is the meaning of intermitting?

Anything that sometimes goes and sometimes stops, is called intermitting.

Can you tell what is the cause of intermitting springs?

They intermit, it is supposed, because the cavity from which they flow is empty.

Why do some of these springs run in dry weather?

Because, when rain descends, some time is re-

quired for the water to penetrate through the earth as far as the basin or cavity of clay, and before it has accumulated there in sufficient quantity to be discharged, the rain is over, aud the weather becomes dry.

Why does it stop running in wet weather?

Because all the water in the basin under ground will run out before it rains again; and so, while it rains, the spring must stop running till the water has time to run through the earth and fill the clay basin; and by that time it will be dry weather again.

Why are not all springs intermitting springs?

Because some basins are so large that they are never empty, from one fall of rain to another.

Does the rain make all springs?

It does not.

What besides rain causes springs?

The springs which are near those mountains that are always covered with snow, are made by the melted snow.

What would become of the water that flows from the springs, if there should be mountains and hills all around them?

They would fill up the valley among the hills, and this would form a *Lake*.

Where would the water go when the valley was filled up with it?

It would flow out of the first opening it could find, and become a river.

Are there any such lakes and rivers in the world?

Yes; many.

Will you mention one?

The Lake of Geneva, in Switzerland, is formed in this manner.

What do you know about it?

The river Rhone runs down from the mountains till it reaches the valley made by the high hills all around it, and there it collects until it has filled the valley and found an opening, and then the river runs on to the ocean.

What is this valley full of water called now?

Lake of Geneva. It is a beautiful lake, almost at the top of the mountains.

Are most of lakes formed in the same manner?

Yes.

Then what is a lake?

A valley partly or wholly filled with water.

Are the valleys always full of water?

They are not: some are *dry* part of the year

Can you mention any?

Lake Merow, in Palestine, is such a valley.

What can you say of Lake Merow?

It is a small lake made by the river Jordan. When the snows on Mount Lebanon melt and run

down into the Jordan, this lake is full, and is several miles long, but when the hot weather comes on, it is dried up.

Do you know of any other such lake?

In Germany there is one called Cirenitz Lake.

Will you describe it?

It is four or five miles in length, and about two miles wide. All around it are wooded mountains, in which deer, wild boars, and hares live. A part of the year the people come in boats to fish, and the other part they may sow and reap grain, and hunt these animals.

Can you tell about a very curious way of fishing these people have?

When the water goes out of the lake, it runs through eighteen holes at the bottom, carrying the fish with it. This makes so many little whirlpools. When the water has all run through, the peasants go down with lights into one of these cavities. This cavity or hole is several feet under the bottom of the lake, in a solid rock. Here the water runs down again through small holes as through a sieve, and the fishes are left behind for the peasants to catch.

Can you mention any more remarkable accounts about this lake?

When it begins to rain hard, three of these cavities spout up water to the height of twelve or eighteen feet. If the rain continues, and it thunders, the water will bubble out of the holes through which it had run, and the whole lake will fill again in a single day. Sometimes not only fish, but live ducks, with grass and fish in their stomachs, will come up with the water out of the holes.

THIRTEENTH LESSON.

WHAT very remarkable lake do you read of in the Bible?

Lake Asphaltites, or as it was often called, the *Dead Sea.*

What do you know about this lake?

It is supposed to have been caused by the destruction of Sodom and Gomorrah.

How does it differ from other lakes?

The water in it is salt to the taste, and different from sea-water.

What is found mixed with the water to give it such a taste?

Salt, and magnesia, and bitumen.

What is bitumen?

It is something like tar, and will burn like oil set on fire.

Do you know of any other wonderful lake in Asia?

In the northern part of Asia is a large lake which throws up a liquid, which the people collect, and put in their lamps to burn.

Are there any other springs in the world like these lakes?

In Italy there are oily springs.

What can you say of them?

Their surfaces are covered with oil, that smells very fragrant when it is burning, and is of different colours.

How much oil is collected from some of these springs?

From one spring near the Appenine mountains, which comes out of a rock, people can collect twelve pounds in one week.

What is the name of this rock oil?

Petroleum.

What is the meaning of the word petroleum?

Petra means *rock*, and *oleum* means *oil.*

Why is it called rock oil?

Because it flows out of rocks.

Is this oil ever found upon the sea?

It is found in the sea near Mount Vesuvius.

How does it first show itself on the water?

While it is rising to the top of the sea, the water seems to be covered with bubbles.

How do people gather it?

They skim it off as they sit in their boats, and then put it into pots and jars.

Does this petroleum rise to the top of the water at all times?

It rises only in warm weather.

What different colours has the oil?

Some is white, some yellow, some red, and some black.

Which oil is the best?

The clear white oil.

Which is the poorest?

The black, because it is not pure.

Are there any springs of petroleum in America?

Yes; there is one in Kentucky.

Do you know of any other kinds of springs besides the oily springs, and springs of good water?

In Iceland there are *boiling* springs.

Why are they called boiling springs?

Because they are as hot as boiling water.

Are they of any use to the people of Iceland?

The Icelanders boil and cook their food with them

What other springs have you heard of?

Warm springs.

Why are they called warm springs?

Because the water that comes up from them is always warm.

Where are any warm springs to be found?

In Virginia.

What very useful springs are found in the United States of America?

Mineral springs.

Why are they called mineral springs?

Because they have sulphur, and iron, and salt, and other minerals in them.

Have they any other name?

They are often called medicinal springs.

Why are they called medicinal springs?

Because they contain substances which are used to remove disease?

Can you mention the names of some of these springs?

There are Balston and Saratoga springs, in the state of New York, and Yellow springs in Ohio, and many others in different states.

What curious springs are sometimes found in the sea, near the shore?

Springs of fresh water.

How can it be got, without mixing it with the salt sea-water?

A bottle corked tight, can be let down directly over the spring, and when it is low enough, the cork can be drawn out, and the fresh water will instantly fill the bottle, which can then be drawn up.

What are *hot* springs?

Those whose water is always hot.

What are *cold* springs?

Those springs which are very cold in warm as well as in cold weather.

What becomes of the water that rises from springs?

It runs into channels, forming streams and rivers.

Where do the rivers carry their water?

Into lakes and seas, and into the ocean.

Does the water of springs always run into rivers or lakes?

Not always, sometimes it disappears before it can get to a river.

What becomes of it?

Sometimes it is converted into vapour by the heat of the sun.

What do we say of water when it is becoming vapour?

We say it is evaporating.

What would become of the earth if water did not evaporate?

The earth would be covered with water, so that there would be no solid surface.

Was the earth ever in this condition?

It was at the Creation.

Does the water of springs ever disappear in any other way?

It sometimes sinks into the earth, as the water of some lakes does.

Can you tell me of one such spring?

In Palestine, near mount Lebanon, there is a spring called *Phiala,* because it looks like the mouth of a phial; and the water from this spring goes down into the ground.

Has any one ever found out what becomes of it under ground?

In the life-time of Herod the Great, the spring, and a stream that came out of the ground thirteen miles from this spring, were examined.

How did people examine them?

They knew that wood always floats upon the top of water, and they threw some wood into the spring, and it went down into the ground.

Was it ever seen again?

The people who were watching the stream that came out of the ground thirteen miles south of the spring, after looking some time, saw those very pieces of wood come out in it.

What did this prove?

That this stream ran under ground for thirteen miles.

What is the name of this stream?

It is the river *Jordan* that we read so much about in the Bible.

What do you learn from this river about streams that disappear?

That such streams do run into rivers and lakes, when we think they evaporate.

What bad effect would happen if the water were not carried off out of a lake?

The water would become very offensive, and fill the air with a dreadful vapour, which would make people sick.

FOURTEENTH LESSON.

WHEN the wind passes over stagnant lakes or pools, and carries the bad air into other places, what are such winds called?

Pestilential winds.

Why are they called pestilential?

Because they make people who breathe them suffer a dreadful disease, that causes them to die very soon.

What are such dreadful diseases called?

Pestilence or plague.

Are there any other kinds of pestilential winds?

The Samiel is a pestilential wind.

Where does it blow from?

The desert of Arabia.

What makes it so dreadful?

It is very hot, and will destroy life immediately, if it be not guarded against.

Do travellers know when the Samiel is coming?

They do.

How do they know?

They see something at a distance that looks like a cloud of dust rising from the ground.

What do they do then?

They lie down, and put their faces close to the ground, until the wind has passed over them.

Is it the heat alone that destroys life?

It is supposed that the wind is poisonous as well as hot.

What remarkable winds blow in Egypt?

The Simoon and *periodical* winds.

Why are they called periodical?

Because they blow only at certain seasons or periods of the year.

What do you know of these winds?

They begin in the month of June, by blowing from the north-west.

How long do they blow in this direction?

Till September, and then they change and blow from the north and east till February.

What happens to the waters of the Mediterranean sea during this time?

The vapours that rise from the sea are cooled, becoming mist and sometimes rain.

In which direction is the Mediterranean sea from Egypt?

North-west and north.

At the end of February, where do these winds blow from?

The south, and afterwards from the south-west and south-east.

In May which way does the wind change?

To the east.

From April till June how does the air move?

The air high above the ground, moves to the south, and the air nearer the ground, moves to the north.

What becomes of the vapour that rises from the sea?

The higher current of air carries this vapour along Egypt down to Abyssinia.

When the vapour reaches that country, what becomes of it?

It changes into rain, and falls in torrents to the ground.

Where does the water then run to?

Some of it runs into the river Nile, and makes the river overflow its banks.

What good does this river do?

It passes through Egypt, where it never rains, and when it overflows its banks, the whole country is watered by it.

While the upper current of air is carrying the vapours from the sea to the south, what is done by the lower current of air?

It takes the vapours that rise in Abyssinia after the rain, and carries them to the north, where the river Euphrates rises.

What happens to this river then?

When the vapour falls in rain, this river rises as the river Nile does.

How many times in a year do these rivers rise in this manner?

Once only.

What is this overflowing of the rivers called?

Inundation.

What would happen if there were no such inundations?

The land of Egypt would be like a desert, and nothing could grow there.

Why would it be so dry and barren?

Because they have no rain, and all their water comes from this river.

How does this show the kindness of God?

It shows that He will provide for the wants of man, in all countries where men live.

How does it show His power?

We see from this, that He is able to bring water where it is needed, even when it does not fall from the clouds. "He causeth the wind to blow and the waters flow."

When a whirlwind passes over the ocean, how does it affect the waters?

It whirls them up into a column, high in the air, and then it bursts and they fall down.

What if the whirlwind passes over a desert of sand?

The sand will rise as the water does.

What causes a whirlwind?

When wind moves simultaneously from every point, a rapid revolution of the air is produced where all the currents meet, and sand, dust, or water is raised up, and scattered around in every direction.

When revolving air passes over land, what is it called?

A whirlwind.

When it passes over water, what does it produce?

A water-spout.

How do we know that whirlwinds and water-spouts

are caused in the same manner, by revolving air?

They both whirl round, and move forward at the same time both occur after great heats, and both are frequent in hot countries.

What is the strongest proof that they are the same thing?

A water-spout has been known to move from sea to land, and when it has got to the land, its motion was like a whirlwind.

Are whirlwinds ever mentioned in the Bible?

The prophet Nahum says, "The Lord hath his way in the whirlwind and in the storm, and the clouds are the dust of his feet."

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THIRD SERIES OF LESSONS

ON

NATURAL PHILOSOPHY.

FIRST LESSON.

Why does smoke rise from the fire and go up the chimney?

Because the air in the fire-place, when heated, rises up and carries the smoke, which is also light, with it.

When the smoke goes out of the chimney, why does it not fall to the ground?

Because it is still impelled by the ascending air below it, and therefore cannot fall.

What is this like?

Like oil upon water.

Why does not the oil sink below the water?

Because the water is heavier than oil.

If you should put the oil in the basin first, and then pour water upon it, would the oil remain at the bottom?

It would not, but would rise through the water and lie upon the top of it.

Why would it?

Because the water is so much heavier, that it sinks down, and forces the oil upwards.

Why will not the smoke spread around the chimney, instead of rising higher?

Because the air above being colder, is heavier, and forces the light smoke upwards, as the water does the oil.

How high will the smoke ascend?

Till it reaches the air that is not heavier than itself.

How long will it remain there?

Till the wind disperses it; or it has time slowly to descend by its own weight.

What makes soap-water bubbles rise in the air?

The warm air from the lungs by which the bubbles are blown.

If you fill a thin bag with very light air, and throw it into the air as you do soap-bubbles, what will it do?

The bag will rise.

How high will it rise?

Till it comes to air of its own weight.

If you should fasten a bit of wood to it, would the bag carry up the wood with it?

It would, if the wood did not make the bag heavier than the air around it.

How are *balloons* made?

A light bag of thin silk, somewhat like a large bubble, is filled with air lighter than the common air.

How is this air kept from coming out of the bag?

The bag is lined with a varnish, made of India-rubber and spirits of turpentine, so that it is air-tight.

How can a person ascend in such balloons?

A little car is fastened to the bag, which can carry one or two persons in it.

How can a balloon carry a loaded car up into the air.

The air in the bag is so very light, that it will go up, and when the car, with one or two people, is fastened to it, the whole together are so much lighter than the air around them, that they can no more stay down on the earth than smoke can.

Do accidents ever happen to those who ascend in balloons?

Very often.

How?

When the balloon comes down, it sometimes falls

into the sea, and the people in it are injured or drowned; and sometimes it strikes a tree suddenly, or is dragged violently along the ground, and the persons in it get hurt.

How can a balloon descend?

By letting out some of the light air from the bag.

How will this make the bag descend?

There will be less light air in the bag to keep up the car, and so the balloon will be heavy an descend.

What is a *parachute?*

It looks like a very large open umbrella.

Of what use is a parachute?

If a balloon bag bursts, or a car upsets, and the man in it has a parachute, he can hold upon the handle of it, and keep himself from falling quickly to the ground or sea.

How will the parachute hold him up?

While it is spread out, the air that it covers will support it so much that it comes down gently.

How can you make a little parachute?

By fastening strings to the four corners of a sheet of paper, then bringing the four strings together in the middle, and fastening a light piece of wood to them.

What must you then do?

Carry it to a high place and let it fall.

How will it fall ?

Very slowly indeed.

If you should have an open umbrella in your hand while falling or jumping from a high place, would you fall very heavily to the ground ?

I should not.

Why ?

The air beneath the umbrella would support it, and the umbrella would almost hold me up from the ground.

How do birds avoid falling, when they are up in the air ?

They spread out their wings, and the air supports them.

Is this the only reason why the air supports them ?

No ; their bodies contain a great deal of air.

How can they remain in the same place in the air without descending at all ?

They strike the air beneath them with their wings a very little, and then the air reacts or strikes back again a very little, and thus they keep their places.

How do they rise in the air ?

They strike harder against the air, and the air reacts just as much and sends them up higher.

How do they descend ?

By partly shutting their wings, and letting themselves be governed by their own weight.

How do they know exactly what to do when they wish to rise or descend, or remain still?

God, who made them, has taught them, and they never make a mistake, or forget how to do what they wish.

SECOND LESSON.

How are fishes able to keep themselves from sinking in water?

They have fins that spread out like the wings of a bird, and the water under them supports them as the air supports the wings and body of a bird.

But you said that the body of a bird had a great deal of air in it, is it so with a fish?

Fishes have bladders of air in their bodies, that make them lighter.

How can they sink in the water when they wish?

They possess the power of compressing the air in the bladder, and rendering themselves specifically heavier than water.

How can they rise again?

God has given to them the power of allowing the air in these bladders to expand whenever they choose.

How do fishes differ from birds?

Their fins are not so large in proportion as the wings of birds.

Why are they not made as large?

Because water is heavier than air, and supports fishes better, so that they need no larger fins than God has given them.

How do people who cannot swim, imitate fishes when they wish to go into the water?

They take bladders filled with air, and fasten them around their bodies under their arms, and the air in the bladders keeps them from sinking.

Do they ever use any other light body instead of blown bladders?

Cork is so light that it will not sink in water, and people use it in the same way as they do bladders.

What are *swimming-girdles, air-jackets,* and *life-preserving belts?*

They are India-rubber bags filled with air, and are tied around the body, instead of corks or bladders.

What is the danger of using these bags and bladders?

If they should slip down to the hips, the heaviest part of the body would be above them, and the body would instantly turn, so that the head

would be downwards and the feet up, and the person would soon be drowned.

What are *life-boats ?*

Boats that contain tight cells full of air along their sides.

Why are they called *life*-boats ?

Because they take people from a sinking ship, and thus save them from a watery grave.

If you should fall into the water, what must you do first to avoid drowning ?

I must turn upon my back, and keep my hands down, with the inside of them spread towards the bottom.

How must you place your feet ?

I must let them sink lower than my body.

Then what parts of your body will be above the water ?

Only the face, and part of the chest.

What must you do then ?

I must try to breathe so as to take more air into my body.

When you throw out the air as you breathe, will not your body sink ?

It will a little for an instant.

What effort must you make, to keep from sinking ?

I must not make *any*, except to keep my face out, so that I can breathe.

What must you be careful *not* to do?

Not to *scream* or *struggle.*

When may you call for help?

When I am a little recovered from my fright.

Who are the most likely to swim, fat people, or those who are not fat?

Those who are fat.

Why?

Because the fat part of their bodies is so much lighter than water.

What amusing account can you give of Marco Paulo?

Marco Paulo was a priest who lived in the city of Naples seventy years ago. His bones were very small, and he was very fat. His body, also, would contain a great quantity of air. These things made him so light, that he would swim on the sea like a duck. When he stood up in deep water, it would not rise higher than his stomach. It is said, that when two men dived into the sea to drag him down with them, the moment they let him go, his body would rise instantly to the surface.

How can heavy bodies, like blocks of marble, be raised, when they have fallen into a harbour or river?

By fastening casks of air to them with ropes when the water is low.

Why should the water be *low?*

Because the distance between the marble at the bottom, and the casks at the top of the water, would be the shortest.

How could it be raised then?

When the water rose, it would bear up the casks with it, and they would carry the marble, so that it could be taken into a boat.

Why would not the boat sink after the heavy stone was placed in it?

One reason is, the wood of boats being so light, and extending over a large space on the water.

THIRD LESSON.

If you take a very small glass tube, open at both ends, and put one end in water, what change will you see in the tube?

I shall see the water rise up into the tube.

What makes it rise?

The inside of the tube draws into it the water which it touches.

What kind of *attraction* is this called?
Capillary attraction.
What is the meaning of *capillary?*
Hair-like.
Why is this attraction called capillary attraction?
Because the bore of the tube is almost as small as a hair.
In what tubes will water rise highest?
In those that have the smallest bore through them.
If you take two pieces of flat glass in contact, and then separate the edges of one side by a very thin wedge, placing the lower edges, thus separated, in water, what will happen?
The water will rise up between them.
What attracts the water?
The inner sides of the glass.
What kind of attraction is this?
Capillary attraction.
If you dip one part of a piece of sponge into water, why will the water rise above that part that was dipped in?
Capillary attraction makes it rise.
What are the capillary tubes of sponge?
The little holes that we see in it. Sponge is full of large and small capillary tubes.
What makes sponge so useful?
It will hold a quantity of water, and will drink up water that is spilled.

When such a substance as sponge drinks up a liquid, what do we say it does?

We say it *absorbs* the liquid.

Then what does sponge do to water when put into it?

It absorbs the water.

Why will cotton and linen cloth absorb water?

Because the cotton and linen threads of which cloth is made are full of cavities, or very fine capillary tubes, which attract the water.

If you take a bowl of water, and place it in the sun, and lay one end of a towel in it, what will happen?

After some time, the towel will be perfectly wet, and the bowl will be empty.

Where will the water be that was in the bowl?

In the towel.

How can it go from the bowl to the towel?

The tubes in the linen draw the water out of the bowl?

Of what use are wicks in lamps?

They are a great number of capillary tubes which draw up the oil from the lamp.

Why must not the wick be smaller than the lamp tube?

Because there would not then be tubes enough to bring up the oil.

Why must not the wick be so large as to be forced tight in the tube?

If the wick were forced very tightly, the capillary tubes in it would be closed, so that the oil could not rise through them.

What happens when you dip one end of a lump of sugar into water or tea?

The liquid rises and fills the whole lump.

What makes it rise?

The capillary tubes in the sugar.

How are large rocks sometimes split in Germany?

Holes are bored in a straight line at certain distances from each other, and wooden wedges are driven into them.

What is done after this?

Water is poured upon these wedges, and the pores or capillary tubes in them fill with water.

What follows?

The wedges begin to swell, and as they pour water upon them, they swell larger and larger, till they burst the rock.

Of what use is blotting paper?

It absorbs the ink upon which it is laid.

When sugar or any other substance is dissolved in a liquid, what becomes of it?

It is divided into such very small particles that we cannot see them?

How do you know that the sugar is in the water if you cannot see it?

Because the water is sweet after the sugar is put in, and it was not sweet before.

Does the water rise higher in the tumbler after the sugar is dissolved than it did before?

It does not.

What does this prove?

That there are exceedingly small spaces between the particles of water, and that the particles of sugar enter these spaces, so that the water does not rise to make room for the sugar.

What will happen when these spaces are full, if you put in more sugar?

The sugar will sink, and the water will rise in the tumbler.

When water has dissolved as much sugar as it can, what do we say of it?

We say the water is *saturated* with sugar.

If you should fill a tumbler with marbles, could you pour sand into it without taking out the marbles?

I could.

Where would the sand go?

Into the spaces between the marbles.

What is supposed to be the shape of the particles of water?

Round.

Then, when you put sugar into water, what is it like?

Like pouring sand into a tumbler full of marbles.

Of what size are the particles of water?

Very small indeed.

When chalk in powder is put into water, will it dissolve?

It will not, but will only mix with the water.

How do you know that it is not dissolved?

I can see it in the water, and the water, instead of looking clear, is opaque and white.

What is the difference between *mixing* a solid with water, and *dissolving* it?

When a solid is dissolved it cannot be seen, and does not raise the water in the vessel.

What are bodies called which can be dissolved?

Soluble bodies.

What are those called which cannot be dissolved?

Insoluble bodies.

FOURTH LESSON.

WHAT instrument shows the effect of water pressure?

A *Hydrostatic Bellows.*

If you wished to make a *Hydrostatic Bellows,* what would be the first thing you would do?

I should get two round pieces of board, and fasten them together with leather, so that they would approach and separate like the common bellows.

What would you do next?

I would take a long tube, and fasten it to one side of the bellows, so that the lower end of the tube would open into the bellows.

How would you make the tube stand erect, after it was fixed to the bellows?

By bending it up from the bottom: or the tube remaining straight, insert it into an angular socket.

What must the top of the tube be

A funnel.

If a man should stand upon the bellows and pour water into the tube, what would follow?

The upper side of the bellows would begin to rise to make room for the water, and would raise the man standing on it higher and higher till the bellows was full.

What supports the man?

The water in the bellows, urged upwards by that in the tube.

How can water run into the bellows, while a heavy man is standing upon it?

The water along the tube presses the water at the bottom of it into the bellows, because its own downward pressure is greater than that of the man.

Then what kind of pressure does the downward pressure of water make?

Sideways or *lateral* pressure.

What is the meaning of lateral?

Sideways.

Then when the downward pressure of the water in the tube presses that in the bottom sideways into the bellows, what other pressure follows?

Upward pressure.

What causes the upward pressure of the water?

The lateral or sideways pressure.

How does it thus act?

When there is no more room in the bellows for the water to press sideways, it must press upward, if the water be continually running in, because it can go no other way.

How could you let the water out of your bellows?

By making a hole at the bottom of the tube.

How can you show the pressure of *air* with the same instrument?

Two men may stand on it, and one of them may blow freely into the tube, instead of pouring in water, and they will both be lifted up.

How can they prevent the air in the tube and bellows from escaping?

By putting a finger firmly upon the top of the tube.

If you fill a vial almost full of water and cork it, then turn it up and down, what will you see moving up and down along the side of the vial?

A bubble of air.

If you lay it on an inclined plane, where will the bubble rest?

Near the upper end of the vial.

Where will it be if you lay it on a level table?

Exactly in the middle of the vial.

How can you tell whether a table be level or inclined?

By laying the vial upon it, and looking at the bubble, to see if it be in the middle, or near one end.

What useful instrument is made in the same way?

A *spirit level.*

Can you tell how a spirit level is made?

A glass tube, like a long vial, is almost filled with coloured spirit, and then closed and laid in a wooden case to keep it from being broken.

When is it used?

When people make roads and canals, they use these levels, to find whether the ground be level or uneven.

What are canals?

They are long large cavities, filled with water that go from one town to another.

Why are canals made?

Because there are no navigable rivers in those places where men want them. Canals for boats to sail upon supply the place of such rivers.

Where do they obtain water to fill their canals?

From the springs or rivers near them.

What is done when a canal must cross a river?

Stone bridges are made in the form of a trough, which carry the water in the canal safely over the river.

What are such bridges called?

Aqueducts.

What is the meaning of aqueduct?

Aquæ means *of water*, and *duct* means *leader.*

Then what do you mean by *aqueduct?*

A *water-leader.*

Why is it called a water-leader?

Because it leads or conducts the water of canals across rivers.

FIFTH LESSON.

If I take a glass tube, open at both ends, and put it into a bowl of water, and then press down the water around the tube, what would happen?

The water would rise up into the tube.

What makes it rise into the tube?

My hands press down the water around the tube, and the water within the tube not being also pressed upon, must be forced upwards within the tube.

What is mercury?

It is a liquid metal that looks like melted silver.

What is mercury sometimes called?

Quicksilver, or liquid silver.

If I put mercury, or quicksilver, into the bowl instead of the water, and then press it down, would it rise in the tube?

It would; but not so high as the water, unless you pressed upon it more than you did upon the water.

Why would it not rise so high?

Because mercury is much heavier than water.

If I could take all the air out of the tube, and stop the upper end, and put the other end of the tube into mercury, would the mercury rise in the tube if I did not press upon it?

It would.

What would make it rise?

The air without the tube pressing on the mercury in which it is immersed.

Then it is the external pressure which makes the mercury rise?

Yes it is.

What does this prove?

It proves that the air has weight.

What is the name of the instrument made of such a tube and bowl of mercury?

A *Barometer*.

What is the meaning of the word barometer?

It means a *measurer of weight.*

When the air is so heavy as to press up the mercury high into the tube, what weather have we usually?

Clear, pleasant weather.

Why is the weather clear and pleasant then?

Because the air is heavy enough to support the clouds, and prevent them from falling down.

How can you tell when the air becomes lighter?

The mercury sinks in the tube.

What makes it sink?

The air does not press so heavily upon the mercury in the bowl, and so the mercury cannot remain as high in the tube.

What weather have we when the mercury sinks in the tube?

Stormy weather.

Why have we stormy weather?

Because the air is not heavy enough to hold up the clouds, and so they fall down in rain.

Then what is the use of a barometer?

It shows us, when well understood, what weather to expect.

Who always need barometers?

Captains of ships.

Why do they need them?

Because a sudden storm would destroy a ship sooner than it would a house.

How can a barometer prevent a ship from being destroyed?

The captain can see the mercury sinking in the tube, and may immediately prepare the ship for the storm, and thus save it.

Can you relate a story of a captain saving his ship, because he had a barometer?

Dr. Arnot gives the account. He was in the ship at the time. He says they were in the southern hemisphere. The sun had just mildly set, closing a beautiful afternoon. The evening amusements were going on as usual, when suddenly the captain's orders came, to prepare with all haste for a storm. The mercury in the barometer had begun to fall with awful rapidity. As yet the oldest sailors could see nothing in the sky like a storm, and were surprised at the greatness and hurry of the preparations. But before everything was quite ready, a hurricane came on them, more dreadful than the oldest of the sailors had ever known. Nothing could resist its power. The sails were torn to tatters, the masts injured, and at one time the hole rigging was near being destroyed. So udly, for a few hours, did the hurricane roar

above, the waves around, and the dreadful thunder peal, that no human voice could be heard; even the speaking trumpet sounded in vain. On that awful night, if it had not been for the little tube of mercury which gave the warning, neither the strength of the noble ship, nor the skill and activity of her commander, could have saved one man to tell the tale.

SIXTH LESSON.

How high above the earth does the atmosphere extend?

About *forty-five miles.*

Then how many miles of air press upon the mercury in the bowl?

Forty-five miles of air.

If the barometer tube were as large as a pump, and the bowl as large as a cistern, would water rise in the tube?

It would.

What would make it rise?

The weight of the air pressing upon the water around it.

What is a pump?

A large tube with the upper end closed.

If there were any air in the pump, would the water rise in it?

It would not.

Why would it not?

Because the pressure of the air within and without the tube or pump, must be equal, and no power would exist to raise the water.

If the top of the pump were taken off, would the water rise in it?

It would not.

Why would it not?

Because the air within and without the tube would still exert an equal pressure.

How could the air be taken out of the pump?

By making a plug just as large as the hole through the pump, which might slide up and down in it.

How could this remove the air from the pump?

If it be in contact with the water, and I then draw it up, there can be no air below the plug.

Why can there be none?

Because the plug is just as large as the bore of the pump, and the air could not get below it.

What would be below it?

Nothing but water.

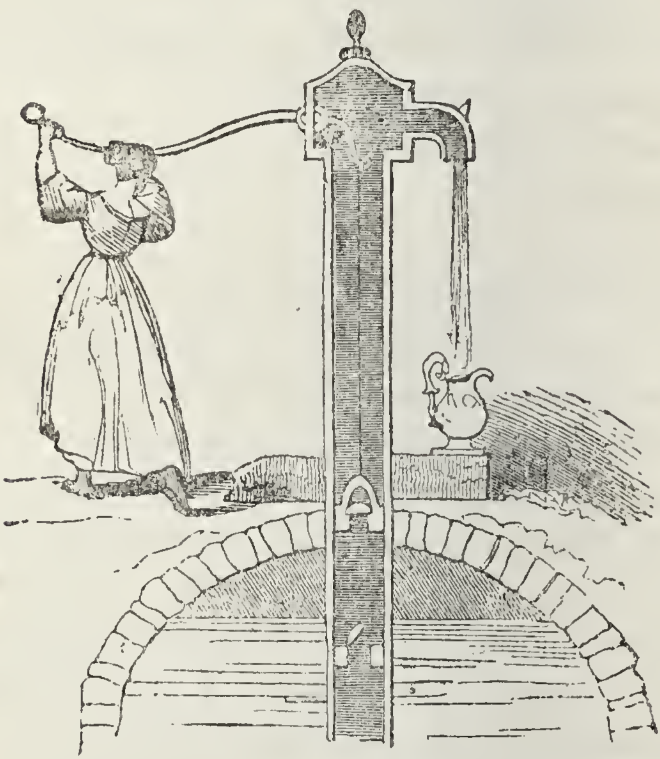
What would the water do?

It would rise as fast as the plug rose.

What would make the water rise?

The air that pressed upon the water in the cistern outside the pump.

Here is a Section of a Pump.



How could you raise as much water as you wish?

By pressing the plug up and down several times.

How could the water get out of the pump, after it was raised up?

By placing a spout on one side of the pump.

What is the plug of a pump called?

It is called a piston.

How high will the water rise in a tube where there is no air?

Thirty-four feet.

Why will it rise no higher?

Because the air does not press heavily enough upon the water in the cistern to raise the water any higher in the pump.

What does this prove?

It proves that thirty-four feet of water weigh just as much as forty-five miles of air.

Then which is heavier, air or water?

Water.

Would the mercury rise thirty-four feet in a tube?

It would not.

What does that prove?

That mercury is heavier than water.

If the piston in the pump had a hole through it, what would happen when you press it down into the water?

The water would rise through the hole.

How could you press down the piston?

By having a long pole fastened to the piston with a handle at the top of it.

When the water has come up through the hole in the piston, how can it be prevented running back into the cistern again?

By fastening a little leather cap over the hole in the piston, that should be lifted up as it descends.

How could the cap be lifted up, when the piston descends in the pump?

When I push down the piston into the wate the water would press up and lift up the cap, and pass through the hole.

Then when you draw up the piston what becomes of the water?

The water that has flowed through the hole in the piston shuts down the cap, and I can draw it up.

What is this cap called?

It is called a *valve* or little door.

SEVENTH LESSON.

How do boys make the playthings which they call *suckers?*

They take a round piece of leather, and fasten a string in the centre of it.

How do they use it?

They press the leather, when wet, very closely to the stone which they wish to lift, and then drawing up the leather by the string, the stone is raised with it.

What makes the stone rise too?

When the string pulls the leather, it stretches the leather because it is wet, so that nothing but its edges touch the stone.

Then what is between the leather and the stone?

Nothing, not even air.

How do you know there is no air under the leather?

Because the edges of the leather are fixed so tightly to the stone, that no air could get under it.

Then what keeps the stone and leather so closely together?

The air pressing upon the leather and upon the stone.

What does this prove?

That air has weight.

What if the edge should be lifted up on one side?

The air would pass between the leather and the stone.

Could you then lift the stone by the sucker?

I could not.

Why could you not?

Because the air under the sucker would press it up, while the air above was pressing it down.

Then when you wish to raise any weight by a sucker, may you admit any air between the sucker and the weight?

I must not.

How can a fly walk upon the glass of a window?

Its feet are suckers, and are kept upon the glass by the pressure of the air.

How can it raise them from the glass so as to walk quickly?

It possesses the power of admitting the air under its feet very quickly, whenever it wishes to move.

Are there any other animals that walk over smooth surfaces by means of such feet?

The lizard that lives in the island of Java walks up a smooth wall in the same way, to catch flies, and the large walrous walks upon ice easily, because his hind feet are shaped like a sucker.

Can you mention another example?

There is a fish in the ocean, called remora, which fixes itself upon the side of a ship, or upon a large fish, and thus travels from one part of the ocean to another, without the trouble of swimming.

How does it fasten itself upon the ship, or fish ?

It has a kind of sucker upon its head, which it fixes to the ship, and the water presses it close to the ship's side.

If you cork an empty bottle, and let it descend deep into the sea, what would happen to the bottle ?

It would be crushed.

What would crush it ?

The water pressing powerfully around it.

What does this prove ?

It proves that the pressure of water is greater than the resistance of the air within the bottle.

If you fill the bottle with water and cork it, and then let it down into the sea, will it be crushed ?

It will not.

Why will it not ?

Because the water in the bottle presses outward as much as the water around the bottle presses inward.

If you take a tight barrel filled with water, and make a hole in one side near the bottom, would the water flow ?

It would not.

Why would it not ?

Because the pressure of the atmosphere opposes the escape of water at the aperture.

How can you make the water run?

By making a hole in the top of the barrel.

What would that do?

It would allow the air above the barrel to press upon the upper surface of the water in the barrel.

Then when you wish the fluid in the barrel to run out at one end, what must you always do?

I must take out the bung or vent peg, to let the air come into the barrel.

EIGHTH LESSON.

If you throw a stone into water, what effect will be produced?

The water at the surface will move in little waves, which are circular; and these circles will grow larger and larger.

When the steeple clock strikes, what does it cause the air to do?

It makes the air around it move in circular waves, just as the water does when a stone is thrown into it.

When one of these circles reaches your ear, what do you say?

I say that I hear the clock striking.

Then what is sound?

Sound is air, moving in small waves against the ear.

What are these circular motions, or waves of the air called?

They are called *vibrations* of the air.

What two things are necessary then to make a sound?

Vibrations of air and the ear to receive them.

How is it known that air is necessary to make a sound?

A bell may be rung in a glass vessel, when the air is taken out of it, and no sound be heard.

If a cannon should be fired several miles off, would you hear it the moment it was fired?

I should not.

Why would you not?

Because it takes some time for the waves made by the explosion to reach my ears?

What connects the explosion of the cannon with your ears?

The air.

Then what may we call the air?

A conductor of the cause of sound.

Why do we hear a bell ring more distinctly when the wind blows towards us from the bell?

Because it increases the force of the waves of air striking our ears: if the wind did not blow in that direction, the force would be diminished.

When the wind blows in a different direction, how does the bell sound?

Very faintly, and sometimes we cannot hear it at all.

Why is the sound so faint?

Because the wind opposes the motion, and therefore lessens the force of the waves of air which strike our ears.

If you strike two stones together under water, can you hear the sound as plainly as you can in the air?

I can.

What does this prove?

It proves that water is a good conductor of sound.

Which is the best conductor of sound, water or air?

Water.

How can it be proved?

If a bell should be rung in water by one person, and another person at a distance should put his head under the water, it would sound much louder than if the bell and the hearer were out of the water.

If you lay your ear upon one end of a table, and I scratch the other end of the table with a pin, will you hear it?

Yes; and it will sound very loud.

What does this prove?

It proves that wood is a good conductor of sound.

Why do quadrupeds seem to know that an earthquake is going to take place sooner than men do?

Their heads are so near the ground, that they hear the rumbling sound first.

What does this prove?

It proves that the earth is a good conductor of sound.

Can you repeat a story that shows what good has arisen from knowing that the earth is a good conductor of sound?

Many years ago there was a war in Greece. The Greeks fought against the Turks, because the Turks had taken their land from them, and treated them very cruelly. In one of the Greek cities there was a strong tower. The name of the city was Missolonghi. A great many Greeks had fled to this tower to get away from the Turks. The Turks came and tried to destroy the tower. There was a great quantity of powder in the cellar for the Greek soldiers to

use. After trying to destroy it a good while, the Turks went away as if they were not going to try any more They began to dig a hole at some distance from the tower. The Greeks did not know what it was for, but one of the Greeks began to think that the Turks were digging a hole under ground to reach the cellar of the tower. He thought that they would lay tow all along, from the powder in the cellar to the beginning of the hole, and then set fire to the tow. This would burn till the fire got to the powder in the cellar, and then that would take fire and blow up the tower and all the people in it.

What did the Greek do?

He piled up some stones in the middle of the cellar, or magazine, and put four smaller stones very loosely upon the top. Then he watched these four stones till he saw them shake. As soon as they began to shake, he put his ear down to the earth, and could hear which way the sound came. As soon as he found in which direction it came, he began to dig down, and soon came to the tow that was laid there, all ready to be set on fire. This he destroyed. When the Turks had set the farther end on fire, they waited at a distance to see the tower

blow up. When they found that it did not blow up, they began to dig somewhere else.

What did the Greek do then?

He kept watching the stones, and soon saw them shake again. Then he put his ear down and heard the noise, and dug again till he came to another train of tow, and destroyed that.

Did the Turks try again?

They did several times, but after some time they began to think that the Greeks knew what they were doing, and so they gave over trying to blow up the tower.

NINTH LESSON.

How fast does sound pass through the air?

About a mile in six seconds of time.

Then if you should see the flash of a cannon, and could count thirty seconds before you hear the first sound, how far off would you say the cannon was?

It would be *five* miles off.

How could you tell?

If it travel one mile in six seconds, it will travel

five miles in thirty seconds, because there are five times six in thirty.

If you see a flash of lightning, and do not hear thunder till you have counted eighteen seconds how far off should you say the thunder-cloud was?

Three miles off.

How would you discover that?

There are three times six seconds in eighteen seconds, and if six seconds would bring the sound one mile, eighteen seconds would bring the sound three times as far, which would be three miles.

If you speak, what will the air around you do?

It will begin to move or *vibrate* in circles, that will spread farther and farther.

If these circles spread till they strike against a high rock, what will happen to them?

The rock will *reflect* or send them back, just as it would a ball, if you threw one against it.

If the circles made by the reflection of the rock should come back to your ear, what would you say?

I should say I hear the *echo* of my voice.

Then what is an *echo?*

An echo is vibrating air sent back again.

What will send back vibrating air?

Rocks, walls, and mountains, if they are near enough.

How near must they be, in order to make an echo when you speak?

So near, that the circles made by my voice can reach them, and that they can send the circles back to me.

If the rock should send its circles to another rock that would send them back to your ear, what would you hear?

I should hear *two* echoes.

How would it be if a great many rocks should do the same?

I should hear several echoes.

Are there any places where several echoes can be heard?

There are many in the world.

Can you mention one in the United States of America?

At Lake George there is a place where, if a person stands and calls out very loudly, he will hear several echoes.

What curious echo is there in England?

At Woodstock there is an echo that will repeat seventeen syllables; and on the north side of a church in Sussex, the echo will repeat twenty-one syllables.

What echo still more wonderful can you mention?

In Italy, near the city of Milan, there are two walls of a building that face each other, and a person standing at a window between them, can hear the echo repeat one word more than *forty* times.

How is it when a pistol is fired there?

The echo repeats the sound *sixty* times.

What can you say of the Whispering Gallery of St. Paul's Church in London?

If a person whispers very softly close to the wall on one side of the gallery, the voice will be echoed so that if another person puts his ear close to the wall on the opposite side of the gallery, he can hear every word distinctly.

What is an Eolian harp?

A musical instrument made with strings.

Can you describe it?

Strings or wires are stretched very tightly over bridges placed on a board, to the ends of which the strings or wires are fastened. The harp thus formed is placed near a limited opening to admit the wind.

What does the wind do to the strings?

It makes them strike against the air, and when the circles made by them reach your ears, you hear very sweet sounds.

What very large one was made in Milan many years ago?

Gattoni stretched seven strong iron wires, from the top of a tower fifty feet high, to the house of Signor Mascati.

What was it called?

The *Giant's Harp*.

Why was it called the Giant's Harp?

Because when the wind blew, it sent forth such lengthened peals of music; now it was a loud chorus, and then it died away in soft murmurings. In a storm it was heard several miles.

TENTH LESSON.

Into how many colours may light be separated?

Light may be separated into seven colours.

What are the names of these colours?

Red, orange, yellow, green, blue, indigo, violet.

When light shines upon a sheet of paper, how do you see the paper?

By the light which the paper *reflects*, or *throws back* to my eyes.

Does the paper reflect the light that shines upon it entire?

f what is called *white* paper, it does.

How do you know that *white* paper reflects the light that falls upon it entire?

Because it requires all the seven colours to make *white* light, and the paper looks white, which it could not do, if it did not reflect *all* the seven colours.

How do you know that it requires all the seven colours to make white?

Because if you divide a ray of light by a prism, it will exhibit just seven colours, and no more; and if you, by means of a convex lens, unite all these seven colours again, they will be changed to a ray of white light.

Do all bodies reflect all these colours?

They do not; some reflect one colour, and some another.

What becomes of those colours which the body does not reflect?

They are *absorbed.*

What do you mean by a body *absorbing* colours?

Taking them into itself, so that we cannot see them.

If a body absorbs all the colours, reflecting none, what colour will it have?

It will not have any colour.

Then what should we call it?

We should call it a *black* body.

Then is black a real *colour?*

It is not.

Then when we say a body is *black*, what do we mean?

We mean that the body has *no* colour.

And when we say a body is *white*, what do we mean?

That it reflects all the seven colours.

If it absorbs all the colours but the red, and reflects the *red*, of what colour will the body be?

It will be *red.*

What colour shall we call it, if it reflects the green, and absorbs all the rest?

We shall call it *green.*

How can you tell which colour a body reflects and which it absorbs?

Being of the colour which it reflects, we shall know that it absorbs all the other colours.

Then how do we see any object?

By the light which it reflects to our eyes.

What is the reflection of light like?

Like the reflection of sound.

Can you explain it?

The sun shines upon a green leaf, and the leaf reflects the green rays to my eyes, just as a person stands out of my sight and calls, has

the sound of his voice, which strikes a rock, reflected to my ear.

Why do not all bodies reflect the *same* colour and absorb the others?

Because the particles of bodies are put together differently, so that one body can reflect one colour, another all of them, and another none.

Which would reflect *all?*

A *white* body.

Which would reflect *none?*

A *black* body.

If you should go into a room perfectly dark, and let in a ray of light through a small hole, and place a *prism* near this hole, what would the prism do to the light that came through it?

It would separate it into the seven colours.

Would all these colours be mixed together?

They would not?

How would they be arranged?

They would lie one beneath the other very distinctly, like the rainbow.

Then do they all go through the prism together in a straight line?

They do not: they are bent and turned out of the straight line.

When a ray of light is turned out of a straight line in passing through a body, what do we say of it?

We say the light is *refracted*.

What is the meaning of *refract?*

To *break*.

When is light *refracted?*

When it is *broken*, or, more properly, bent.

If you put a piece of white paper into the *blue* ray that has passed through your prism, of what colour would the paper be?

It would be *blue*.

Why would it be blue?

Because it can reflect only the blue colour.

Why would it not be white?

Because it must reflect the seven colours to make white, and there is but one for it to reflect, when the blue alone falls upon it.

If you should put the paper into the yellow ray, of what colour would it be?

It would be yellow.

What does this prove?

It proves that bodies are of the colour which they *reflect*.

Then if no light should fall on a body, would it have any colour?

It would not.

Why would it not?

Because there would be no colour for it to reflect.

When a body does not reflect any colour, what do we call it?

A *black* body.

If a room is so dark that no light can enter it, of what colour will the objects in the room be?

They will be of *no* colour, because there is no colour to be reflected.

Then what must we call them, as long as they are in the dark?

We must call them *black* bodies.

Can we ever see them when they are made black in this way?

We cannot; because we can see nothing when it is *perfectly* dark.

Why can we see a tree upon the top of a hill at a distance more distinctly than we can see one on a plain or in a valley at the same distance?

Because the sky behind the tree on the hill is so much lighter than the tree, that we can see the shape of the tree very distinctly.

Why is not the tree in the valley as distinct as the one on the hill?

Because the green colour of the grass behind the tree seems to mingle with the green colour of the tree, and we cannot distinguish the one from the other.

Why can we see a white house at a distance, plainer than we can see a tree at the same distance?

Because there is so great a difference between a white object and a dark one.

If you wish to make a room very light, what should you do, besides having many windows in it?

I would have it painted white, and the walls should be white, or papered with very light-coloured paper.

Why would light paint and paper make a room lighter than dark paint and paper, if there were the same number of windows in it?

Because white walls throw all the light that falls upon them back into the room, and dark walls absorb part of the light, and therefore reflect less into the room.

Why do people who have tender eyes wear a green shade over them in the day-time, especially when reading?

To prevent the light that is reflected from the walls of the room from entering into their eyes.

Why do they wear them when reading by candle-light?

To prevent the rays of light that proceed from the candle, from entering their eyes.

Is *heat* reflected in the same manner as light?

It is.

Then why is a white dress cool in summer?

Because it reflects or throws off the heat of the sun.

Why is a black dress warm?

Because it absorbs all the heat, and reflects none.

When the heat of the sun falls upon the side of a mountain white with snow, what becomes of this heat?

It is reflected in every direction.

If a valley be surrounded by such mountains, will it be warm or cold?

It will be warm.

Are there any such valleys?

There are valleys in Switzerland surrounded by such mountains, that receive so much reflected heat from every side, that they are always green, though they are in the midst of perpetual snow.

ELEVENTH LESSON.

How high from the earth does the atmosphere extend?

About forty-five miles.

From what does our light principally come?

It comes from the sun.

When the rays of light, in coming from the sun, enter the atmosphere, what happens to them?

They are refracted, or bent and turned out of their course.

What refracts them?

The atmosphere.

Does it also separate the light into different colours, like the prism?

It does not; it only bends them.

If the atmosphere becomes more *dense* or *thick*, how would the light be refracted?

It would be refracted more and more, the more dense the atmosphere becomes.

When light passes through a prism, which of the coloured rays is refracted the most, or turned the farthest out of its course?

The violet.

Which is refracted the least?

The red.

What is it that refracts the light?

The glass of which the prism is made.

If light passes through water, is it refracted more or less than when it passes through the atmosphere?

It is refracted more.

If a stick is put into water, so that one part of it

is in the water and the other part out, how will the light be reflected from each part?

It will seem to come straight to your eye from the upper part of the stick, and the stick will appear broken where it goes into the water.

What will make it seem broken?

The rays of light from the lower part of the stick are turned so much out of their course by the water, that when they enter the air they turn partly back again, and come with the others to your eye, and thus the stick appears bent or broken, because the rays of light that come from it, are really bent.

Why does water refract light more than the atmosphere?

Because it is more dense than air.

Then what bodies refract light most?

The densest bodies through which light can pass, refract it most.

Why does the sky or atmosphere look blue?

The rays of light come from the sun, pass through the atmosphere to the earth, and are reflected back through the atmosphere, and the *blue* rays are stopped on their way and reflected again to our eyes.

What become of the other colours?

They pass through without being reflected.

Why are the blue rays stopped?

Because they do not seem to have momentum enough to carry them through.

What did you say was the meaning of *momentum?*

The quantity of matter and velocity combined.

Then what do you mean by the momentum of a blue ray?

Its power to carry itself through the atmosphere.

Which colour has the greatest momentum?

The red.

If the atmosphere should become very thick or dense, what would be the effect upon the light that passes through it?

None of the rays but the red would have momentum enough to pass through the atmosphere.

When does the sun look red?

When it is seen through a fog or vapour.

If the atmosphere did not reflect any of the sun's rays, how would the sky appear?

Perfectly dark.

When bodies do not allow any light to pass through them, what do we call such bodies?

Opaque bodies.

Can you mention an opaque body?

A piece of wood, or marble, or iron, is opaque.

How can you tell?

By holding them up to see whether the light will pass through them.

When a body permits light to shine through it, what is it called?

A *transparent* body.

Will you mention a transparent body?

Glass is transparent.

Why is it called transparent?

Because light can pass through it.

Is water transparent?

It is.

Then why is it more difficult to see bodies distinctly through a fog, than when the air is clear?

The fog refracts the rays of light that bodies reflect through it so much more than the air does, that we cannot distinguish the size and shape of those bodies very well; they seem much larger than they really are.

Can you relate a story about a singular mistake, caused by a dense fog or mist?

A shepherd upon one of the mountains of Cumberland was suddenly surrounded with a thick fog. Every thing seemed so very large that he lost his way. He tried to find some object that he knew, and by which he could find where he was, and where he ought to go.

He soon came to what seemed to be a very large mansion, which he did not remember to have seen before. He went into it to inquire the way home, and there found his own family. It was his own cottage. The fog had deceived him so much, that it was some time before he could believe the fact.

Do clouds ever reflect shadows of objects that are before them?

They do.

Will you mention one instance?

Forty years ago, a Mr. Hane went up the Hartz mountains in Germany, at a place called the Brocken. As he looked towards the south-west, he saw, at a very great distance, the figure of a man, as large as a giant. Just then a gust of wind almost blew off his hat, and he raised his hand to his head to keep on his hat. The figure did the same. He then bent his body as if to salute it. The figure returned it at the same instant. He then went back and took another man with him. They then saw two such giant figures, and all that these men did, the figures imitated.

What was the cause of this appearance?

When the sun is rising or setting, and throws his rays over the Brocken, upon the fine light clouds

floating around, if a man comes between the rays of light and the cloud, the shadow of the man will be seen on the clouds opposite him, and all his motions will be represented by his shadow.

How long will his shadow be?

It will extend *five or six hundred feet.*

How far from the man will it be?

Two miles off.

What name have the ignorant people in that country given to this immense shadow?

They call it the *Spectre of the Brocken.*